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A Baseline Assessment of University Students' Vitamin D Knowledge

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A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science

A BASELINE ASSESSMENT OF UNIVERSITY STUDENTS' VITAMIN D KNOWLEDGE

(Thesis format: Monograph)

by

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Abstract

Vitamin D is necessary for many aspects of health and development yet 25% of Canadians are not getting enough; university-aged students are at particularly high risk of insufficiency. It seems program development is needed to help university students in acquiring adequate vitamin D. The purpose of this study was to acquire a baseline assessment of university students' vitamin D-related knowledge to help inform future program development. Subjects were asked to complete a Vitamin D Knowledge Survey which assessed knowledge on aspects such as vitamin D sources, health benefits, and recommended intake. A Vitamin D Knowledge Score was computed for the 1,088 student participants, who earned an average of 27%, indicating a significant vitamin D knowledge deficiency. Subjects scored with 25% accuracy on vitamin D source knowledge, 34% on factors affecting vitamin D levels, and 23% on health effects of vitamin D. Only 8% of participants identified the recommended vitamin D intake, and 14% correctly identified the amount of time in the sun required to produce adequate vitamin D. Results suggest that vitamin D knowledge is significantly related to age, ethnicity and area of academic study, as well as knowledge origin. Vitamin D usage is also related to vitamin D knowledge. This is the first study to date to assess the vitamin D knowledge of university students, and it is clear that those surveyed are largely unaware of this important nutrient. Potential interventions should be considered as a next step to ensure this segment of the population is acquiring adequate vitamin D.

Keywords: vitamin D, vitamin D insufficiency, vitamin D deficiency, vitamin D knowledge, vitamin D knowledge assessment, vitamin D knowledge survey, health promotion program development

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Chapter 1

Introduction to the Vitamin D Problem

Vitamin D deficiency is a worldwide epidemic and yet, it is a problem that is largely unknown by the majority of citizens (Holick, 2005; Holick & Chen, 2008). Currently, over 1 million Canadians are vitamin D deficient (Langlois, Greene-Finestone, Little, Hidiroglou, & Whiting, 2010; Whiting, Langlois, Vatanparast, & Greene-Finestone, 2011). In addition to its importance for bone health (Heaney, 2007), recent evidence suggests that vitamin D is also useful in promoting musculoskeletal health (Heaney, 2007; Holick, 2007a) and immune functioning (Holick, 2007a; van Etten & Mathieu, 2005; White 2008) as well as preventing and managing cardiovascular disease (Giovannucci, Liu, Hollis, & Rimm, 2008), several types of cancer (Gorham et al., 2007, Holick, 2007a/b) and many other diseases (Annweiler, et al., 2010; Hoang et al., 2011; Holick, 2007a). Although many researchers have increased their attention to vitamin D and the variety of health benefits with which it has been recently associated, rates of deficiency continue to be problematic (Holick, 2007a; Holick, & Chen 2008). The Institute of Medicine (IOM; 2011) recently increased the Recommended Dietary Allowance (RDA) of vitamin D from 400 to 600 International Units (IU) and approximately 25-67% of Canadians are not meeting the new vitamin D mandate (Whiting et al., 2011). Furthermore, about 13% of Canadians are not even getting the 400IU of vitamin D required to maintain proper bone health (IOM, 2011; Langlois et al., 2010; Whiting et al., 2011). These findings are alarming because vitamin D is relatively easy to access from inexpensive supplements (Deluca, 2004; Holick, 2007a), the sun (DeLuca, 2004), and from several food sources (Holick, 2007a). Of particular concern is the fact that young adults, aged 20-39 years, are at highest risk of deficiency (Whiting et al., 2011). The health behaviours of young adults are of primary concern, as they are forming lifelong behaviours that will contribute to the quality of their lives for many years to come (Von Ah, Ebert, Ngamvitroj, Park, & Kang, 2005).

Vitamin D and University Students

Although no study to date has assessed the vitamin D levels of university students, 74% of university students fall within the age range of those most at risk of deficiency (Statistics Canada, 2010). Therefore many are likely not receiving sufficient levels of vitamin D. Furthermore, university students are a population known to have lower health scores than their non-student counterparts (Stewart-Brown, et al., 2000) and thus, they are a population at particularly high risk for poor health outcomes. As such, university students are in need of health promotion programming to better their health, including decreasing vitamin D deficiency. University students typically have more freedom and control over their lifestyles than prior to attending school, making the university years an appropriate time to develop healthy lifestyle patterns and behaviours (Dinger & Waigandt, 1997). Moreover, most university students are at an ideal age to create long term positive change when it comes to vitamin D, as their bones are still building mass (Nilsson, Ohlsson, Odén, Mellström, & Lorentzon, 2012), they are reportedly interested in learning about nutrition (Katz, Davis, & Scott-Findlay, 2002) and enhancing their dietary habits (Tucker & Irwin, 2011). As such, university students are a primary target for vitamin D deficiency prevention and intervention programs to promote their long-term wellbeing. Targeting younger populations for health behavioural change increases the likelihood that such changes will persist throughout the life course as the development of healthy behaviours earlier in life will help to protect from disease development and progression later in life (von Bothmer & Fridlund, 2005).

In fact, adequate vitamin D earlier in life has been shown to help prevent osteoporosis (National Institute of Health, 2012, Osteoporosis Society of Canada, 2008; 2012), multiple sclerosis (Munger, Levin, Hollis, Howard, & Ascherio, 2006; Simpson et al., 2010) cardiovascular disease (Giovannucci, 2008; Zitterman, 2006), rheumatoid arthritis (Merlino et al., 2004), some types of cancer (Li et al., 2007; Lin et al., 2007) and several other diseases later in life. The Canadian Paediatric Society has stated that ensuring adequate vitamin D throughout the life course is needed to prevent associated adult and childhood diseases (2007). Even maternal vitamin D during pregnancy may have lifetime implications for the child (Canadian Paediatric Society, 2007), including reduced bone density (Javaid et al., 2006), increased occurrence of asthma (Carmago et al., 2007) and susceptibility to type 1 diabetes (EURODIAB Study, 1999).

As leaders of the future, university students represent the next generation of professionals and parents who will influence the progression of future health education programs, policy development, and the formation of social norms and beliefs about health and health promoting behaviours (Haase, Steptoe, Sallis, & Wardlem, 2004; Stewart-Brown et al., 2000; von Bothmer & Fridlund, 2005). Accordingly, university students are an integral part of future health-related progress and should therefore be the target for inducing long term change (Irwin, 2004; Racette, Deusinger, Strube, Highstein, & Deusinger, 2005).

Vitamin D Program Planning for University Students

From the above-noted review of research, it seems that program development is needed to help university students in acquiring adequate amounts of vitamin D in order to sustain wellbeing and promote their long term health. In terms of moving forward with a suitable health promotion program, it is recommended to start with an assessment of needs from the perspective of the target population (Green & Kreuter, 1999; 2005; McKenzie, Neiger, & Thackeray, 2009). As the Generalized Model for Program Planning stipulates, a needs assessment must first be completed before the health problem can be properly addressed (McKenzie et al., 2009). A needs assessment is necessary to determine problem origin, the knowledge, values, and needs of the priority population and its subgroups, as well as to provide insight on what types of programming are likely to work, how to best implement them, and to identify what barriers may exist (McKenzie et al., 2009). Although there are several approaches to health promotion program development, many of them involve several key elements, as the Generalized Model for Program Planning outlines. In fact, the Precede-Proceed model of health promotion programming by Green and Kreuter (2005) also encourages health promotion program planners to attempt to understand aspects of need, such as the predisposing factor of knowledge. The Health Belief Model (HBM) and the Expanded Health Belief Model (EHBM) further suggest that knowledge of health issues and preventive health behaviour is important for health behavioural change (Burns, 1992; Hochbaum, 1958; Rosenstock, 1966).

The main tenants behind the HBM and EHBM stipulate a person's likelihood to engage in a health behaviour is influenced by that person's perception of a health threat and if he/she believes a specific health practice will reduce that threat. The main components involved in this decision include: perceived seriousness of the health threat; perceived susceptibility to the health threat; perceived benefits of the health behaviour; and perceived barriers to the health behaviour. All of these components are informed by knowledge (Hayden, 2009). For instance, the perceived seriousness and susceptibility of the health threat are influenced by information such as risk factors, warning signs and family history of disease, all of which are influenced by knowledge. Similarly, perceived benefits and barriers of the health behaviour are informed by knowledge of the health behaviour itself, as well as knowledge of the disease, success rates, costs and accessibility. In addition to the above stated constructs, the expanded model also includes other components that relate to knowledge, such as: cues to action; motivating factors; and self-efficacy (Burns, 1992). Accordingly, the knowledge a person has about the health benefits of vitamin D and the problems associated with vitamin D deficiency may factor into the behaviour of ensuring vitamin D adequacy. For example, if people value bone health and believe that vitamin D assists with bone health, they may be more likely to supplement with vitamin D to ensure the health of their bones. In addition, people must know where and how to get vitamin D, as well as how much is required to sustain a given health benefit, which are informed by knowledge. On the contrary, if people do not know that vitamin D is necessary for proper bone growth and they do not know where to get vitamin D, they will be less likely to take measures that ensure vitamin D adequacy. In fact, the HBM and the EHBM have been used to explain many health behaviours in post-secondary populations. For instance, this model effectively explains diabetes self-management in college students (Wdowik, Kendall, Harris, & Auld, 2001), healthy eating habits of college students (Deshpande, Basil, & Basil, 2009) and it helps to explain osteoporosis prevention behaviours in college students (Edmonds, 2009) and adolescent females (Gammage & Klentrou, 2011).

Although there are many necessary factors to consider when developing any health promotion program, each program must have a starting point. Because vitamin D deficiency has been identified as a problem and university students have been identified as at risk, it is suitable to explore a predisposing factor, knowledge, that can "facilitate or hinder a person's motivation to change and can be altered through direct information," such as information presented in health promotion programing (McKenzie et al., 2009, p. 22). This involves assessing university students' vitamin D-related knowledge.

The common thread among the above discussed theories for health behaviour and health promotion program planning, is that to best facilitate health-related behaviour change, program planners need to start with an exploration of the target population's needs, which includes understanding their knowledge about the specific issue of interest (i.e., vitamin D). It is important to note that knowledge is just one aspect of a needs assessment and that it is not the only factor that impacts behaviour. Although knowledge is not the only factor that influences behaviour, it does have an effect on behaviour and is therefore important to consider when developing a health promotion program (Green & Kreuter, 2005). As von Bothmer and Fridlund (2005) pointed out, it is crucial to have a thorough understanding of students' health-related behaviours, motivation, knowledge and attitudes towards a health behaviour before being able to create effective and targeted health promotion programs. Therefore, gaining a baseline understanding of university students' current vitamin D-related knowledge may be a crucial first step in program development, and is the purpose of this study. To date, no other studies have investigated the level of vitamin D knowledge present in a group of Canadians. The findings from this piece of the needs assessment will provide important information to determine what next steps will be necessary to promote sufficient levels of vitamin D among university students.

Chapter 2

Literature Review

To contextualize the importance of vitamin D, the following review of literature includes: an overview of various health benefits associated with vitamin D as well as the potential harms of vitamin D toxicity; the Dietary Reference Intakes (DRI) for vitamin D; the status of vitamin D in Canada, including a discussion of groups at increased risk of deficiency as well as supplement usage; methods for obtaining vitamin D; and vitamin D population-based knowledge levels presently available. Finally, a discussion of the need for further research and a detailed description of the current study are presented. For practical reasons, the review of vitamin D and associated health benefits is not intended to be exhaustive. The health benefits discussed are those most frequently occurring in recent publications (i.e., within the past decade) and that have repeatedly demonstrated an association with vitamin D in humans.

Health Benefits of Vitamin D

Over the past decade, researchers have come to recognize that vitamin D does much more than its essential role in promoting proper bone health, and preventing bone diseases such as osteomalacia, also known as rickets in children (Holick, 2007a; Vieth 2007). The discovery that vitamin D is actually metabolized into a hormone and that vitamin D receptors are located in many different kinds of cells in the body, has led researchers to believe that vitamin D plays a substantial and important role in various aspects of health (Deluca, 2004; Holick, 2007a; Jones, Strugnell, & DeLuca, 1998). Although not all researchers are in complete agreement, evidence has been brought forward to suggest that vitamin D is useful in promoting musculoskeletal health and immune functioning as well as preventing and managing cardiovascular disease, several types of cancer and many other diseases -- these will be discussed further in the following sections. For sake of clarity, please note that although international units (IU) and nanomoles per litre (nmol/L) are each presented in the literature discussed below, IUs refer to amounts of vitamin D ingested whereas nmol/L is the unit used when discussing vitamin D blood concentrations. Where available, both values are provided but because people metabolize vitamin D differently, their intake (IU) does not consistently transfer mathematically to blood concentration (nmol/L). As a rough estimate, Vieth (2004) reported that each microgram of vitamin D (approximately 40IU) increases blood concentrations by 1nmol/L, although results have varied from 0.57nmol/L to 2.2nmol/L in other studies as discussed by Heaney, Davies, Chen, Holick and Barger-Lux (2003). For the sake of simplicity and adequate understanding, it is reasonable to roughly equate 40IU of vitamin D per day to an increase of 1nmol/L in blood concentration.

Musculoskeletal health and vitamin D. Vitamin D is best known for the role it plays in bone health (Holick, 2007a). It assists with the absorption of calcium and phosphorus into the bones (Deluca, 1988; Heaney, 2007; Holick, 2007a; White, 2008), making them stronger and preventing bone softening disease such as rickets and osteomalacia (Health Canada, 2010b, IOM, 2011; McCollum, Simmonds, Becket, & Shipley, 1922; Park, 1940; Wagner & Greer, 2008). Strong bones also help to promote overall musculoskeletal health by stabilizing the body and thus reducing risk of injury (Bischoff-Ferrari et al., 2009; Deluca, 1988; Holick, 2007a). Low vitamin D status has been associated with risk of fractures and falls in older adults, which often lead to chronic pain, immobility and disability (Reginster, 2005). For example, a 2009 meta-analysis of randomized control trials (RCTs) revealed that higher doses of vitamin D (400-1000IU per day) reduced risk of fractures by 20% in older adults (Bischoff-Ferrari et al., 2009b). In another meta-analysis of RCTs, supplemental doses of 700-1000IU a day reduced risk of falling by 19% in older adults, although doses less than 700IU (or concentrations below 60nmol/L) were not associated with reduced risk of falling (Biscoff-Ferrari et al., 2009a). In addition to decreasing falls, many health professionals consider adequate vitamin D intake as the first step in preventing and treating osteoporosis (Rizzoli et al., 2008; Roux et al., 2008), a bone disease affecting over 1.5 million Canadians (Health Canada, 2010a). Although the necessity of vitamin D in promoting and maintaining overall musculoskeletal health is well documented and largely agreed upon (Holick, 2007a; IOM, 2011), adequate intake among the population is still lacking.

Immune health and vitamin D. With regard to the immune system, vitamin D has demonstrated immunomodulary effects (Di Rosa, Malaguarnera, Nicoletti, & Malaguarnera, 2011; Toubi & Shoenfeld, 2010; White, 2008). More specifically, it has been implicated in heightened immune response as well as in the prevention of several autoimmune-related diseases, such as type 1 diabetes and rheumatoid arthritis, through suppression and stimulation of certain aspects of the immune system (van Etten & Mathieu, 2005). For instance, a study conducted in Finland demonstrated that children receiving 2000 IU of vitamin D per day reduced their chance of developing type 1 diabetes by 80% compared to children receiving significantly less vitamin D (Hypponen, Laara, Reunanen, Jarvelin, & Virtanen, 2001). Similarly, researchers of another study found that vitamin D supplementation (no value mentioned) also decreased risk of type 1 diabetes (The EURODIAB Study, 1999). Conversely, Simpson and colleagues found no association between vitamin D and development of type 1 diabetes in children (2011). Type 2 diabetes, which has recently been tied to innate immunity (Odegaard, & Chawla, 2012), has also been associated with low vitamin D. For instance, inadequate vitamin D status was associated with worse insulin resistance and increased risk of type 2 diabetes, as well as higher body fat percentage and higher blood glucose in a recent study by Garanty-Bogacka and colleagues (2011). Correspondingly, vitamin D was positively correlated with insulin sensitivity in another study (Alemzadeh, Kichler, Babar, & Calhoun, 2008). Overall, results of that study implied that obese children and adolescents with low vitamin D status may be at increased risk of developing impaired glucose metabolism, and subsequent diabetes (Alemzadeh et al., 2008). In a Canadian study, low concentrations of vitamin D were associated with other predictors of diabetes, such as increased risk of metabolic syndrome and insulin resistance (Brenner et al., 2011). Several other studies have also found a positive association between low vitamin D status and increased risk of diabetes (e.g., Mattila et al., 2007; Pittas et al., 2006).

Low vitamin D status has been implicated in increased incidence of several other autoimmune diseases, such as rheumatoid arthritis (Merlino et al., 2004) and multiple sclerosis (Ramagopalan et al., 2009), as well as various allergies tied to immune response (Frieri & Valluri, 2011). For instance, researchers investigating the relationship between vitamin D and rheumatoid arthritis in a prospective cohort study (n = 29,368) found that higher intake of vitamin D (over 468IU) was associated with decreased risk of the disease (Merlino et al., 2004). Furthermore, a RCT revealed that 500IU of vitamin D was tied to significantly more pain relief in patients with rheumatoid arthritis than in the other treatment groups (Gopinath & Danda, 2011). In addition, results of a retrospective study revealed that lower (no value provided/linear model) vitamin D levels were associated with increased relapse rate in paediatric-onset multiple sclerosis (Mowry, et al., 2010). Mowry and colleagues (2010) also found that each 24nmol/L increase in vitamin D was associated with a 34% decrease in risk of relapse. Similar results were found in a prospective cohort study, in which researchers found that each 10nmol/L increase in vitamin D was associated with a 12% decreased risk of relapse (Simpson et al., 2010). Conversely, lower (no value provided/linear model) vitamin D levels were associated with increased severity of illness (Smolders, Menheere, Kessels, Damoiseaux, & Hupperts, 2008). In relation to multiple sclerosis, investigators have also demonstrated that Caucasians with higher vitamin D levels (over 99nmol/L) displayed a significantly decreased risk of multiple sclerosis in a large prospective, nested case control study (Munger et al., 2006), although Huang and Xie (2012) found no association. Lastly, researchers have also demonstrated a positive association between vitamin D deficiency and prevalence of allergies and allergy symptoms, such as rashes and sinus infection caused by specific immune response (Frieri & Valluri, 2011). Overall, the evidence indicates vitamin D has beneficial effects on the immune system and associated diseases, although there is still more to be learned about these relationships.

Cardiovascular health and vitamin D. Several studies have demonstrated a relationship between low vitamin D status and cardiovascular disease. For instance, in a prospective nested case-control study, 18,225 men free of diagnosed cardiovascular disease were followed for 10 years (Giovannucci et al., 2008). Results of the 10 year follow-up revealed that men deficient in vitamin D (less than 37nmol/L) were at increased risk of myocardial infarction, as were men with intermediate levels (up to 56nmol/L) when compared to those with sufficient levels (over 75nmol/L). The results remained significant even after adjusting for family history of myocardial infarction, body mass index (BMI), alcohol consumption, physical activity, history of diabetes mellitus, hypertension, cholesterol level and several other variables known to be associated with myocardial infarction (Giovannucci et al., 2008). Similarly, other studies have found inverse relationships between known cardiovascular risk factors and vitamin D levels. For example, hypertension was found to be inversely associated with vitamin D levels (Forman, Curhan & Taylor, 2008; Forman et al., 2007). In addition, a recent study demonstrated that vitamin D levels were inversely associated with all-cause mortality among adults with hypertension (Zhao, Ford, Li, & Croft, 2012). Similarly, a 2008 study found that low vitamin D levels (less than 33nmol/L) were independently associated with all-cause cardiovascular mortality (Dobnig et al., 2008). Currently, a large RCT is underway in the United States to further investigate the preventative relationship vitamin D has on cardiovascular disease and cancer (Manson et al., 2012). This study (with an expected completion of June, 2016) should help to further illustrate and explain the role vitamin D plays with regard to these illnesses. For now, it is reasonable to conclude that vitamin D may have a positive effect on the cardiovascular system and a protective effect against associated diseases.

Cancer and vitamin D. Low vitamin D has been connected to poorer outcomes in several types of cancer. For example, in a large prospective study (n = 10,578), researchers found that higher intakes of vitamin D (over 548 IU) were moderately associated with decreased incidence of breast cancer and smaller tumors in premenopausal women with breast cancer (Lin et al., 2007). Similarly, a 2010 population-based case-control study revealed that vitamin D supplement use was associated with reduced risk of breast cancer (Anderson, Cotterchio, Vieth, & Knight, 2010). A meta-analysis led to the conclusion that daily intake of 1000-2000 IU of vitamin D reduced incidence of colorectal cancer in men (Gorham et al., 2007). This meta-analysis also demonstrated a 50% lower risk of colorectal cancer associated with vitamin D concentrations over 82nmol/L compared to concentrations less than 30nmol/L, supporting claims that vitamin D assists in cancer prevention. In a study by Li and colleagues (2007), 14 916 men initially free of cancer were followed for 18 years. Upon follow up, it was discovered that men with lower concentrations of vitamin D (less than 62nmol/L) were at significantly increased risk of aggressive prostate cancer. Lastly, in a review of the literature that investigated the relationship between cancer and vitamin D, authors found associations between vitamin D and risk of breast cancer, prostate cancer, and malignant melanoma at the genetic level (Köstner et al., 2009). The research to date suggests an important relationship between vitamin D intake and some types of cancer, although research continues to further clarify this role.

Vitamin D and other health benefits. In addition to the health-related associations described above, low vitamin D has also been linked with a host of other diseases. For instance, in a recent study, inadequate intake was linked to worse outcomes for women with HIV (Mehta et al., 2010). During the study, HIV infected women were followed for approximately 70 months, while information on disease progression, mortality, and vitamin D status were collected. Results demonstrated that low vitamin D status (less than 80nmol/L) was significantly related to the progression of HIV, all-cause mortality, and development of anemia. Low vitamin D has also been significantly associated with incidence of depressive symptoms, particularly in people with previous episodes of depression (Hoang et al., 2011). In addition, vitamin D deficiency (less than 25nmol/L in this study) has been associated with the presence of mood disorders and cognitive impairment in older adults (Wilkins, Sheline, Roe, Birge, & Morris, 2006). A 2010 study also found inadequate vitamin D intake to be associated with cognitive impairment in older women (Annweiler et al.), although healthy young adults did not show improvements in cognitive function with vitamin D supplementation (Dean et al., 2011), and a systematic review found the association between vitamin D and cognition to be inconclusive (Annweiler et al., 2009). Overall, inadequate vitamin D status has been tied to poorer health outcomes in areas of mental health, cognition and some diseases. Although researchers have demonstrated a relationship between vitamin D and various diseases, there is still more to be learned about its relationship with these diseases and many others.

It's seems that vitamin D adequacy is necessary throughout the life course, as it insures adequate bone health and may assist with many other aspects of health as reviewed above. For those of university-age, adequate vitamin D is important to maintain proper bone density, help strengthen the immune system and prevent the development of many diseases, especially later in life. In addition, vitamin D adequacy is important for university-aged women who are pregnant or considering children, as it insures several aspects of health for their children both in infancy and throughout the life course (Canadian Paediatric Society, 2007).

Vitamin D Toxicity

Although vitamin D toxicity is rare, it can occur when highly excessive amounts of vitamin D are ingested (Holick, 2007a; Vieth, 1999). According to the IOM (2011), people (aged 1-70 years) should not consume more than 4000 IU per day, as it could lead to potential adverse effects such as hypercalcemia and hyperphosphatemia (Holick, 2007a; IOM, 2011). Hyercalcemia refers to elevated calcium in the blood and is the primary result of vitamin D intoxication, although hyperphosphatemia, or elevated phosphate, can also occur (Holick, 2007a; Vieth, 2007). Typically, symptoms of toxicity include mild nausea, dehydration, and lethargy (Blank, Scanlon, Sinks, Lett, & Falk, 1995; Koutkia, Chen, & Holick, 2001). Although the IOM suggests not exceeding 4000 IU of vitamin D per day, some research demonstrates that doses over 10,000 IU per day have not led to toxicity (Vieth, 1999; 2007). According to Vieth (1999), the majority of cases of vitamin D toxicity have been associated with blood concentrations well over 200nmol/L (approximately 40,000IU/day) and have led to full recovery. In an article review, Holick (2007a) indicated that it would take more than 50,000 IU per day to raise blood levels to that which are associated with adverse health effects.

As research continues, the exact role vitamin D plays in various aspects of health will become better understood. From the above-reviewed research it is clear that vitamin D is necessary to create healthy bones and improve musculoskeletal health and it may also play a significant role in immune functioning, cardiovascular functioning as well as prevention of several types of cancer and many other diseases. Therefore, adequate levels of vitamin D are important to maintain and promote overall health.

Dietary Reference Intakes for Vitamin D

Dietary Reference Intakes (DRIs) are recommendations for nutrient intake established by Canadian and American scientists through a review process overseen by the IOM (Health Canada, 2010b). The DRI is an umbrella term that describes four types of reference values: Estimated Average Requirement (EAR); Recommended Dietary Allowance (RDA); Adequate Intake (AI); and Tolerable Upper Intake Level (UL). The EAR is defined as "the average daily nutrient intake level that is estimated to meet the nutrient needs of half the healthy individuals in a life stage or gender group" (IOM, 2011, p. 20). The RDA is a value that is estimated to meet or exceed the nutrient needs of 97.5% of the population and is the same value Health Canada recommends for Canadians aged 1-70 years (Health Canada, 2010b). The AI is a value based on observed estimates of nutrient intake by a specific group and is used only for children under the age of one year (for vitamin D), while the UL represents the highest tolerable intake level that can be consumed without potential risk of adverse effects (IOM, 2011). Until recently, the DRI of vitamin D in Canada was 200-400IU, depending on age (IOM, 1997). In 2009, the IOM launched a large scale review of the DRIs for vitamin D and calcium, in response to widespread rates of vitamin D deficiency and many researchers calling for increases in the DRIs (Yetley et al., 2009). The review was jointly commissioned by the United States and Canadian governments with the goal of having citizens benefit from the most up-to-date nutritional advice (Health Canada, 2010b). After reviewing the literature, the IOM increased the EAR to 400IU, the RDA to 600IU and the UL to 4000IU for people aged 1-70 years. As it is generally agreed that the best way to measure levels of vitamin D is through blood concentrations of its metabolite, 25(OH)D3 (Holick, 2007a), the 2011 DRI's established by the IOM deemed vitamin D concentrations below 30nmol/L to be deficient, concentrations of 40nmol/L consistent with the EAR, and concentrations of 50nmol/L consistent with the RDA. Vitamin D levels below the RDA are considered insufficient, while vitamin D levels below 30nmo/L are considered deficient. Lastly, the IOM defined the UL as blood concentrations over 125nmol/L (IOM, 2011; Ross et al., 2011). The vitamin D RDI's for all ages are presented in Table 1. Health Canada has recommended Canadians aged 1-70 years intake 600IU of vitamin D daily (Health Canada, 2010b) to meet the RDA. All DRI's for vitamin D have been set assuming minimal sun exposure and are based primarily on bone health and no other health effects because the exact relationships between vitamin D and other health benefit are still in the process of being definitively deciphered (IOM, 2011).

Status of Vitamin D in Canada

In recent years, there has been much discussion on the status of vitamin D in Canada. One topic of interest has been the resurgence in the occurrence of rickets (Ward, Gaboury, Ladhani, & Zlotkin, 2008). Many researchers have attributed the rise in rickets to vitamin D deficiency, as this is the most common cause of rickets (Holick; 2006; Ward et al., 2008). Vitamin D deficiency causes rickets by preventing the efficient absorption of calcium and phosphorous into the bones which results in skeletal deformities (Holick; 2006; Ward et al., 2008). Holick (2006) points out that vitamin D deficiency and risk of rickets has become a global epidemic and that the vitamin D status is in need of increased attention both in Canada and worldwide.

Between 2007 and 2009, the Canadian Health Measures Survey (CHMS) collected blood from 5306 Canadians aged 6 to 79 years across the majority of provinces/ territories. Vitamin D blood concentrations were assessed. The results were based on the IOM's 1997 DRI's for vitamin D, which were being assessed at the time because they were thought to be too low (Langlois et al., 2010). The 2010 follow-up revealed that 4.1% of the population was vitamin D deficient (concentrations below 27.5nmol/L) (Langlois et al.). In addition, just over 10% of this large sample had concentrations below that considered necessary for proper bone health (below 37.5nmol/L). Furthermore, 65% of Canadians were below the 75nmol/L concentration that many health researchers recommend for vitamin D adequacy and overall health (Bischoff-Ferrari, Giovannucci, Willett, Dietrich, & Dawson-Hughes, 2006; Dawson-Hughes et al., 2005; Vieth et al., 2007).

Surprisingly, the data demonstrated that vitamin D concentrations were higher for children and seniors, likely because seniors take more supplements (Whiting et al., 2011) and children often consume more milk, which is typically fortified with vitamin D. (Langlois et al., 2010). People aged 20-39 years had the lowest observed concentrations of vitamin D (Langlois et al., 2010). Females, people who reported drinking milk at least once a day, and people who self-categorized as "White" had slightly higher concentrations of vitamin D at all ages, as did people who had their blood taken in the summer months (the sun is a natural source of vitamin D; Langlois et al., 2010). Less than 0.5% of the sample had concentrations above 220nmol/L, which corresponds to intakes with no adverse effects (10,000nmol/L), and no one had concentrations considered to be potentially toxic (defined as 375nmol/L in this study; Langlois et al., 2010).

After the Canadian government increased the DRIs for vitamin D in 2011, blood samples from the CHMS were assessed using the new DRIs to investigate adequacy levels. The analysis revealed that Canadians were even less likely to be getting adequate amounts of vitamin D with the increased mandate (Whiting et al., 2011). When vitamin D status was assessed using the new DRIs, Whiting and colleagues (2011) found that an average of 5.4%, 12.7% and 25.7% of all Canadians in the sample were below the concentrations of 30-, 40-, 50-nmol/L, respectively. Although the proportions of citizens below the DRI's were higher than previously estimated, the main trends were similar to the previous analysis. People self-identifying as White, females, the old and the young demonstrated fewer cases of deficiency compared to their counterparts, as did supplement users. Adults aged 20-39 years still had the highest rates of deficiency and the largest differences in vitamin D status were found between people identifying as “White” and “Non-White.” To avoid inaccuracies, the terms “White” and “Non-White” as used in the study by Whiting and colleagues, will be used when discussing their findings. People who self-identified as “Non-White” may include those of South-American, Asian, African, Middle-Eastern, Native American or Native Canadian ancestry. Groups of people at increased risk of deficiency are explained further in the subsequent section.

Table 1

The 2011 Vitamin D Dietary Reference Intakes by Life Stage

Life Stage Group	Adequate Intake	Estimated Average Requirement	Recommended Dietary Allowance	Tolerable Upper Intake Level
Infants				
0-6 months	400 IU	____	____	1000 IU
6-12 months	400 IU	____	____	1500 IU
Children				
1-3 Years	____	400 IU	600 IU	2500 IU
4-8 Years	____	400 IU	600 IU	3000 IU
9-18 Years	____	400 IU	600 IU	4000 IU
Adults				
19-70 Years	____	400 IU	600 IU	4000 IU
70 + Years	____	400 IU	800 IU	4000 IU
Pregnancy	____	400 IU	600 IU	4000 IU
Lactation	____	400 IU	600 IU	4000 IU

Note. Dashes indicate there is no value for the corresponding age group/ type of intake. The Dietary Reference Intakes for vitamin D are set assuming minimal sun exposure and are based primarily on bone health (IOM, 2011). Adapted from Institute of Medicine, 2011, *Dietary Reference Intakes for Calcium and Vitamin D,* Table S-2: Vitamin D Dietary Reference Intakes by Life Stage. Washington, DC: National Academy Press.

Groups at increased risk of deficiency. As introduced above, Whiting and colleagues' 2011 study revealed that adults aged 20-39, Non-Whites and supplement non-users were most at risk of not meeting the vitamin D requirements set out by the IOM. Adults between 20 and 39 years had significantly higher rates of deficiency in all categories, especially males. In terms of skin pigmentation, people who self-identified as Non-White had much higher rates of deficiency than those who self-identified as White. For example, although 5% of White Canadians were found to be vitamin D deficient, 16.3% of Non-White Canadians were vitamin D deficient. As for the EAR, 30.5% of Non-White Canadians were below the 40nmol/L cut off, while only 8.7% of white Canadians were below the cut off. There were no differences in supplement use found between Whites and Non-Whites, although Non-Whites did report less frequent consumption of milk. Because it takes longer for vitamin D to synthesize in darker pigmented skin (Hall et al., 2010) the authors concluded that the vitamin D concentration differences between Whites and Non-Whites were likely because Non-Whites are "unable to make sufficient vitamin D from casual sun exposure" putting them at particularly high risk if they were supplement non-users (Whiting et al., 2011, p. 133). A 61% majority of Non-White Canadians, in the above-noted study, who did not take any vitamin D supplements (i.e., oral tablets or drops) were below the 50nmol/L recommendation, while a much lower minority of 37% of White supplement non-users were below the recommendation. This illustrates why Non-White, supplement non-users are identified as having extremely high risk of deficiency. Whiting and colleagues (2011) concluded that, because 20% of Canadians were of visible minority in the 2006 census (data taken from Statistics Canada, 2008), “having 1 in 5 nonwhite Canadians at risk of rickets and osteomalacia is a public health concern” (p. 133).

In addition, evidence supports that living at high latitude is another risk factor for vitamin D insufficiency because living at high latitude decreases the amount of time available for synthesis of vitamin D (Roth et al., 2005; Rucker, Allan, Fick, & Hanley, 2002). North of the 35th parallel, very little vitamin D can be produced from November to February and the length of time for vitamin D production further decreases in more northern areas (Webb, Kline, & Holick, 1988). Beyond the 55th parallel, the possibility for vitamin D synthesis is little to none from October to April. For this reason, many professionals urge those living in northern latitudes to supplement with vitamin D (Canadian Paediatric Society, 2002; 2007; Holick, 2007a; Huotari, & Herzig, 2008; Rucker, et al., 2002; Webb et al., 1988,). Although Health Canada does not specifically suggest increased use of supplementation for those in northern communities, the Canadian Paediatric Society has recommended increasing vitamin D intake to 800IU/ day for children and pregnant or lactating mothers in northern communities during the winter months (2002; 2007).

With regard to both the analyses from the CHMS data (used by Langlois et al., 2010 and Whiting et al., 2011), it is worth noting that there was a low response rate of Non-White respondents. In addition, blood samples were not collected from residents of First Nations Reserves, crown lands, certain remote regions, members of the Canadian Forces, and institutions, such as hospitals and long-term care facilities (Langlois et al., 2010). Some members of these groups are known to be at particularly high risk of vitamin D deficiency (Genuis, Schwalfenberg, Hiltz, & Vaselenak, 2009; Schwalfenberg, 2007), particularly First Nations People (Weiler, Leslie, Krahn, Steinman, & Metge, 2007), people in institutions (Liu et al., 1997) and Non-Whites (Ginde, Liu, & Camargo, 2009; Gozdzik et al., 2008; Yetley, 2008). Accordingly, actual rates of deficiency may be higher when including groups of people who have previously demonstrated higher risk of deficiency, such as those listed above. In fact, there are several studies that have reported higher rates of deficiency than were observed in the CMHS data set (see Bischoff-Ferrari et al., 2006; Dawson-Hughes et al., 2005; Vieth, 2007; Yetley, 2008). While considering that actual rates of deficiency may be higher in the Canadian population, it is also worth considering that the DRI's for vitamin D established by the IOM are mainly based on bone health, including risk of rickets/osteomalacia (IOM, 2011; Ross et al., 2011) and not on the amount necessary for overall health promotion and prevention of illness. For the purpose of this review and the current study, vitamin D adequacy will be discussed in reference to the IOM/Health Canada recommendations, unless stated otherwise. It is of worth to note that many researchers advocate for higher intakes of vitamin D (1000-2000IU) to optimize health and assist with disease prevention (Bischoff-Ferrari et al., 2006; Dawson-Hughes et al., 2005; Holick, 2007a; Schwalfenberg, 2007; Vieth, 2011; Vieth et al., 2007). Overall, the above review seems to suggest that the proportion of Canadians with vitamin D deficiency may be much higher than currently reported.

Supplement use and vitamin D. Not surprisingly, the analysis made by Whiting et al. (2011) revealed that supplement users had significantly higher concentrations of vitamin D year round, whereas non-users demonstrated trends towards higher deficiency rates in the winter (Whiting et al., 2011). Furthermore, prevalence below

IOM-established cut off levels was twice as likely for supplement non-users verses supplement users in all DRI categories (Whiting et al., 2011). Unfortunately, only about 30% of Canadians reported taking a supplement containing vitamin D (Whiting et al.). Even fewer people (3%) took a vitamin D specific supplement of 1000IU or more (Whiting et al.), which is the minimum dose recommended by many professionals investigating vitamin D (Bischoff-Ferrari et al., 2006; Dawson-Hughes et al., 2005; Holick, 2007a; Schwalfenberg, 2007; Schwalfenberg, Genuis, & Hiltz, 2010; Vieth et al., 2007). The majority of those who took higher doses of vitamin D were older adults (Whiting et al.). Overall, supplement users had higher concentrations of vitamin D during both the summer and winter months, although differences diminished in summer months for children and teenagers, potentially because they are exposed to the sun more than adults (Whiting et al.). Nonetheless, vitamin D supplementation seems to significantly decrease the occurrence of vitamin D deficiency. Because supplement use, age, sex and skin pigmentation are strongly related to rates of deficiency, Whiting et al. have recommended further investigating these factors as they relate to vitamin D status.

Methods of Vitamin D Intake

The three methods to acquire vitamin D include ultraviolet radiation, dietary intake, and supplementation. In the following section, each method will be discussed, as well as its potential pros and cons for health and accessibility.

Vitamin D and ultraviolet radiation. Vitamin D is produced in the skin through ultraviolet radiation (UV; DeLuca, 1988; 2004; Holick, 2007a). More specifically, when skin is exposed to the sun or other sources of UV, such as tanning beds, it initiates the process of producing vitamin D as follows. First, previtamin D is formed through a photolytic process, which is then slowly turned into vitamin D_3. The circulating form of vitamin D_3 is 25-hydroxyvitamin D_3 [25(OH)D_3], which is what is measured in the blood to assess vitamin D status. Before the circulating form of vitamin D can be utilized in the body, it is metabolized into a hormone. The active, hormonal form of vitamin D is called 1-alpha, 25-dihydroxyvitamin D_3 [1,25$(OH)_2D_3$]. As such, vitamin D, when metabolized, is actually a hormone and not a vitamin (DeLuca, 1988; 2004; Holick, 2007a) and can function like a hormone in the body even at the genetic level.

Although people can readily synthesize vitamin D from the sun (DeLuca, 1988; 2004; Holick, 2007a) there are several factors that can reduce the synthesis of vitamin D into the blood through sun exposure. Living at high latitude (such as in Canada) decreases synthesis of vitamin D (Roth et al., 2005; Rucker, Allan, Fick, & Hanley, 2002). In the summer, sunscreen use and clothing coverage can also reduce the amount of vitamin D synthesised because the sun is being blocked from the skin (Mithal et al., 2009). In the winter, lower UV index, winter clothing, and reduced time outdoors can prevent synthesis of vitamin D in the skin (Mithal et al., 2009). Pregnancy, lactation, and high BMI are also associated with lower vitamin D concentrations (Mithal et al., 2009; Holick, 2007a.). Similarly, concentrations of vitamin D are also negatively associated with older age (Dixon et al., 2006; Grinde et al., 2009; Mansbach, Ginde, Camargo, 2009) and darker skin pigmentation (Langlois et al., 2010; Weiler et al., 2007; Yetley, 2008). As there are many factors that affect how much vitamin D is produced physiologically in response to UV exposure, it is difficult to specify how much UV exposure is necessary to produce adequate amounts of vitamin D. As a rough estimate for Caucasians, exposure of the arms and legs twice a week for about 5-30 minutes between 10am and 3pm would be adequate (Holick, 2007a), although it can take 3-6 times longer for people with pigmented skin, such as Asians and Africans (Vieth, 1999). That being said, it is important to consider that UV overexposure has many known adverse health effects, which include skin damage, premature aging, skin cancer, and eye diseases (Health Canada, 2008). Therefore, UV exposure may not be the most suitable/safest source of vitamin D for much of the population.

Vitamin D and dietary intake. Although people can readily synthesize vitamin D from the sun when weather conditions permit, it is not as easy to get it from food sources. In Canada, there are relatively few natural food sources containing Vitamin D. Mushrooms, egg yolks, and several types of fatty fish are the main natural food sources of vitamin D (Holick, 2007a; IOM, 1997). Much smaller amounts of vitamin D can also be found in some types of meat, although it is mainly found in the liver (Centers for Disease Control and Prevention, 2008). As such, meat is generally not considered a source of vitamin D. In addition, some foods may be fortified with vitamin D, including milk, milk substitutes, margarine, some yogurts and orange juices as well as some breakfast cereals (Holick, 2007a; IOM, 1997; Schwalfenberg, 2007). Dairy sources tend to be the main dietary sources by which people ingest vitamin D (Vatanparast, Calvo, Green, & Whiting, 2010; Calvo, Whiting, & Barton, 2004).

Unfortunately, dietary sources alone are insufficient for acquiring adequate amounts of vitamin D (Whiting et al., 2011). In 2004, Canadians reported consuming an average of 250IU of vitamin D per day through their diets (Vatanparast et al., 2010), which is far from the 600-800IU recommended by the IOM. From this study, it seems most Canadians do not get enough vitamin D through food sources alone. Even when dietary intakes are coupled with average sun exposure, about 25% of Canadians studied in 2011 were still not getting adequate amounts of vitamin D (Whiting et al.). Furthermore, the diets of people who are vegan, vegetarian, have dairy allergies, or are lactose intolerant may be associated with vitamin D deficiency, and as such, have been noted as requiring further research (IOM, 2011).

Vitamin D and supplementation. Another way to get vitamin D is through various types of supplementation (Holick, 2007a). Although quantity recommendations vary among health professionals, supplement use is considered a good way to ensure vitamin D adequacy. Anecdotally (i.e., from the author's experience), vitamin D tablets and liquid drops are easily available at local pharmacies and can be purchased without a prescription for less than $15 Canadian per bottle. Although there are many varieties of vitamin D supplements, typically vitamin D tablets contain 400, 800, 1000 or 2000IU (Holick, 2007a), with the label recommending one tablet per day (many popular brands supply vitamin D tablets in such quantities). That being said, one bottle of vitamin D, consisting of an average 240 tablets, should last one adult, following the directions on the label, about 6 months. Vitamin D liquid drops come in doses of 400, 600, and 1000 IU per drop. Each bottle recommends about 1 drop per day orally and contains about 180 drops. Many multivitamins typically contain 400IU of vitamin D (for example, Centrum® Multivitamins), as well as other vitamins and minerals. As such, vitamin D supplements are relatively inexpensive, seemingly convenient to use, and do not seem to have any downside provided the directions are followed. Lastly, vitamin D can be injected annually in large quantities by a physician (150,000-300,000IU), although this method of supplementation is not common (Vieth, 1999).

Among Canadians, factors that most contribute to lower vitamin D status include: living in a high northern latitude which lessen the time for vitamin D synthesis (Huotari, & Herzig, 2008; Roth et al., 2005; Rucker et al., 2002; Webb, Kline, & Holick,1988); a lack of vitamin D-rich dietary choices (Gozdzik et al., 2008; Weiler et al., 2007); and for some people, having darker skin pigmentation (Gozdzik et al., 2008; Weiler et al., 2007). As the sun can have damaging health effects (Health Canada, 2008; Holick, 2007a) and is not readily accessible in the winter months for many Canadians, it seems that more vitamin D fortified foods and supplement use may be key to decreasing vitamin D deficiency in the Canadian population. Vitamin D insufficiency is an important health factor in Canada that is necessary to investigate further, especially taking into account the difficulty in acquiring adequate amounts of vitamin D through dietary intake and safe sun exposure.

Knowledge of Vitamin D

Considering the widespread rates of vitamin D insufficiency among those Canadians who have been studied to date, it stands to reason that a lack of related knowledge about the vitamin and its health benefits may play a role in the deficiency levels. In accordance with the Health Belief Model (Hochbaum, 1958; Rosenstock, 1966) it is unlikely that people would aim to fix a problem about which they are unaware and/or in which they do not have a vested interest (Burns, 1992; Hayden, 2009). Indeed, the few studies that have looked at vitamin D knowledge have found staggeringly low rates of awareness (Christie & Manson, 2011; Kung & Lee, 2006; Vu, van der Pols & Whiteman, 2012; Kimlin & Neale, 2010). For example, a qualitative study conducted in Saudi Arabia found only minimal awareness of vitamin D knowledge, including where it comes from and what it does for health (Christie & Manson, 2011). Although some subjects were aware of the effects vitamin D has on bones, no study participant was aware of any other beneficial health effects or concerns related to deficiency. Only those who had been diagnosed with a vitamin D deficiency had received information on vitamin D from a health professional. When asked about using sun exposure to get vitamin D, the young women who took part in the Saudi study stated cultural (i.e., wearing a burka), infrastructural (i.e., lack of useful outdoor space) and health (i.e., skin cancer risk) reasons for not going in the sun (Christie & Manson, 2011). Unfortunately, the qualitative nature, small sample size (n = 8), and sex restriction (only female subjects) limit the generalizability of this study. In a telephone survey study conducted in China, subjects also displayed lack of knowledge and confusion surrounding the role of vitamin D and its sources (Kung & Lee, 2006). In this study, nearly 30% of subjects had not even heard of vitamin D. Of those who had heard of vitamin D, only 32% could correctly identify a function of vitamin D and only 38% could correctly identify at least one source of vitamin D. The authors found that attitudes toward sunlight were largely negative and most respondents took measures to avoid the sun, as they desired lighter skin. Again, potential cultural differences and the age and sex restrictions (only women over 50 years participated) limit the generalizability of the study. Lastly, a study in Australia investigating knowledge of vitamin D within an adult workforce, also found low rates of accurate knowledge of vitamin D, including where it came from and its health benefits (Vu et al., 2010). In this study, only 69% of subjects had heard of vitamin D and of the 69%, less than half correctly identified bone health as a vitamin D health benefit. To date, no studies assessing the vitamin D-related knowledge of Canadians, and in particular Canadians deemed to be at high risk, has been undertaken. As such, it is necessary to specifically investigate what groups of Canadians at risk (such as university students) know about vitamin D and its health benefits. Having an understanding of their knowledge level, will help in understanding the likelihood that university students will/will not engage in vitamin D-seeking behaviours.

This Study's Purpose and Research Questions

Considering the aforementioned wide-spread rates of vitamin D insufficiency in Canada, the recent increases in RDIs, the highly important role vitamin D plays in musculoskeletal health and the potential for it to contribute to improved immune functioning, cardiovascular health, and disease prevention, it is necessary to develop an effective strategy for decreasing rates of deficiency, especially for those at increased risk. Because university students are among the ages of those most at risk and they are at a prime age to develop lifelong health behaviours that contribute to their long-term health, they are deemed to be a suitable target for effective health promotion programs. First, using the health promotion program planning principles outlined by McKenzie et al. (2009) and Green and Kreuter (2005), it is necessary to gain a thorough understanding of students' vitamin D-related knowledge before being able to create an effective and tailored health promotion program. As such, the purpose of the current project was to serve as a baseline assessment of university students' vitamin D-related knowledge from a health promotion framework, which is one of the first steps recommended in the development of health promotion program planning (Green & Kreuter, 2005; McKenzie et al., 2009). Specifically, the current study helped to fill in the identified research gaps by assessing the vitamin D-related knowledge of students at one large urban Canadian university. The research sub-questions that were asked through a developed survey tool to fulfill the study's purpose were:

1. What percentage of university students have heard of vitamin D and what do they know about it, its sources, recommended quantity, and health effects?
2. From where do university students get vitamin D knowledge and what is the association between knowledge origin and knowledge accuracy?

Hypothesis. It was hypothesized that this study would find low rates of vitamin D knowledge, including accurate knowledge of vitamin D sources, the quantity of vitamin D recommended by Health Canada and the associated health benefits of vitamin D. In addition, it was hypothesized that most students would get their knowledge of vitamin D from family, school, and possibly through some types of media but that most students would not be getting their knowledge from their physicians or other health professionals. Furthermore, it was considered likely that vitamin D knowledge originating from reliable sources, such as physicians, books, and schools would be more accurate than that from other sources and students in health sciences based programs would perform better than students in other disciplines on the vitamin D knowledge survey.

Chapter 3

Method

Procedure and Participants

Upon receiving ethical approval from Western University's Research Ethics Board (Appendix A), an email invitation (Appendix B) including a link to the online survey was sent to the undergraduate student population at Western University. Undergraduate university students were selected to strengthen external validity, as a lower response rate than was achieved was anticipated and therefore, the inclusion of a small sub-set of graduate students may have threatened external validity. All undergraduate students at the host university were invited to complete a web-based survey on vitamin D-related knowledge and values. Only the knowledge portion of the survey was assessed for the purpose of this study. The survey was administered through Survey Monkey®, a well-known internet survey website, during a one week period beginning November 16th, 2012. Due to a higher than expected response rate, a reminder email was not sent out, as stated in the e-mail invitation. Data collection ended one week after initial e-mail invite. Prior to taking the survey, a letter of information (Appendix C) informed participants that all responses were anonymous and would remain confidential, that participation was voluntary and that participation in the survey implied consent. The study consisted of 1,088 Western University undergraduate students. Participant demographics summarized in Table 2 of the Results section.

Measures

The Vitamin D Knowledge Survey was developed by the researcher for the purpose of answering this study's research questions. Previous studies investigating vitamin D-related knowledge (Christie & Mason, 2011; Kung & Lee, 2006; Vu et al., 2010) guided the development of the survey, as did literature about vitamin D deficiency and sources; as well as the needs assessment strategies discussed by McKenzie and colleagues (2009) and the program planning strategies discussed by Green and Kreuter (2005). The survey is discussed in more detail below. A more exhaustive account of the survey development can be found in the subsequent section, titled “Survey development”. The survey itself, along with a list of correct responses (for the knowledge-based questions) can be found in Appendix D.

The Vitamin D Knowledge Survey. This survey was developed to assess the level of vitamin D-related knowledge university students have. The 9 question, predominantly multiple-choice survey took approximately 5 minutes or less to complete. The survey questions assessed the level of knowledge people had with regard to where vitamin D comes from, what it does for health, how much is recommended, factors that affect vitamin D levels and the prevalence of vitamin D insufficiency. The first question is a screening question that asked people if they had heard of vitamin D. Only those who had heard of vitamin D are asked to complete the rest of the knowledge survey. In addition, question #2 asked where people heard of vitamin D, as origin of knowledge may be related to knowledge accuracy. Lastly, demographic information about age, gender, ethnicity, and academic program of study was collected, as was information on the intake of vitamin D supplements. The vitamin D knowledge survey questions enabled the calculation of a knowledge score.

Knowledge score calculation. Questions #3-9 were used to calculate the knowledge score. As each question investigates different aspects of vitamin D, all seven questions included in the knowledge score were weighted equally. Each question was worth one point, for a maximum score of 7 points (100%). Therefore the overall knowledge score was calculated as a proportion out of 7 points, and multiplied by 100 to calculate a knowledge score percentage. If a subject got 3.5 answers correct, their knowledge score was 50% (3.5/7 x 100). When questions included multiple correct responses, each of the correct responses was worth a fraction of the overall question. For example, if a question included four correct answers then each correct answer was worth 0.25 (1/4) points. For every correct answer provided, the knowledge score increased by the associated value. In addition, equally weighted points were deducted for incorrect answers to avoid getting a perfect score, while selecting incorrect responses. The response, "I don't know" was not factored into the knowledge score. The following equation illustrates the above scoring principle for calculating the knowledge score proportion for questions with multiple responses:

$$\frac{\text{(No. of correct responses selected – No. of incorrect responses selected)}}{\text{Total possible correct responses}}$$

Questions #3, 4 and 8 had multiple correct responses; therefore their point calculation used the above formula. The total number of correct responses for question #3, 4 and 8 are 8, 11, and 15 respectively. The correct responses for each question are included at the end of the survey in Appendix D. Questions #5, 6, 7 and 9 were simply marked as right (1 point) or wrong (0 points). The total points scored for questions #3-9 were added together to get a total "knowledge score" proportion as follows (simply multiply the proportion by 100 to get the knowledge score percentage):

Sum of points for questions #3-9
Total questions (7)

Survey development. As stated above, the survey was developed to assess vitamin D knowledge. The following section identifies how the survey questions relate to the research purposes and details how the questions were selected and formulated. For the purpose of this study, vitamin D knowledge refers to what subjects know about vitamin D, its sources, functions, health benefits, recommended dosages and insufficiency prevalence. To respond to the study's purpose of assessing university students' vitamin D knowledge, items numbered 1-9 were included. Items numbered 1-5 were adapted from previous studies assessing vitamin D knowledge [number 1 was adapted from Christie and Mason (2011), Kung and Lee (2006), and Vu and colleagues (2010), while numbers 2 and 3 were adapted from Vu et al. (2010) and number 4 was adapted from both Kung and Lee (2006) and Vu and colleagues (2010)]. Question #1 assisted in answering the research question, "what percentage of university students are aware of vitamin D," while numbers 3-9 identified, "what they know about it, its sources, recommended quantity, and health effects." Question #2 corresponds to answering the research question, "From where do university students get vitamin D knowledge." Numbers 5, 8 and 9 were developed specifically for the purpose of this study. Lastly, number 6 and 7 were partially adapted from Kung and Lee (2006). All items within the survey were developed for the purpose of this study and with the guidance of the needs assessment strategies discussed in McKenzie and colleagues', *"Planning, Implementing, and Evaluating Health Promotion Programs"* (2009). Overall, the only questions used in this study, from the previous surveys by Kung and Lee

(2006), Christie and Mason (2011) and Vu and Colleagues (2010), were those viewed as directly related to the research purpose. Other questions from the above stated studies were not included in this study as they were not specifically related to the research questions being investigated.

Survey delivery. An internet-based survey method was selected for the current study because it offered suitable privacy and convenience to survey participants (Baer, Saroiu, & Koutsky, 2002). Specifically, Survey Monkey® allowed for the collection of anonymous survey responses with no personally identifying information from respondents and therefore, no privacy issues (Survey Monkey®, 2011). Internet-based surveys have also yielded high response rates from previous studies investigating health behaviours in student populations (Hallett et al., 2012; Kypri, Gallagher, & Cashell-Smith, 2004) and students report high rates of satisfaction with this type of survey method (Kypri et al., 2004). A study investigating the feasibility of internet-based surveys has also deemed this method as sufficient for health promotion purposes in post-secondary populations (Kypri et al., 2004). Internet-based surveys also take less time than traditional surveys and reduce data transcription errors (Alvarez & VanBeselaere, 2005). In addition, all students enrolled at Western University have free internet access and could therefore complete the surveys without accessibility issues.

Survey validity. To ensure face validity, the researcher's advisory committee reviewed each question in the survey, and a knowledgeable individual in the field of vitamin D, Professor Reinhold Vieth, Department of Nutritional Sciences, University of Toronto, conducted an expert review to assess the appropriateness of the survey questions and responses prior to use. Professor Vieth has been studying vitamin D for over 30 years and has published many articles investigating the relationship between vitamin D and various aspects of health (For example, see Vieth, 1999; 2004; 2007; 2011; 2012; Vieth, Kimball, Hu & Walfish, 2004; and Vieth, Ladak, & Walfish, 2003).

In addition to the above noted reviews, a pilot-test of the tool was completed with a sample of 12 undergraduate university students to ensure that the target audience understood what each question was asking, as well as what each response meant. Students were asked to read the survey questions as well as the responses and explain what they believed the question was asking, as well as what the responses meant. This process was to ensure clarity. In small groups of 3, the students were also asked to discuss their ideas on how to make the survey easier to read and understand. The individual student feedback as well and the group mediated feedback from the target audience was collected. Feedback from the target audience and the expert reviews was utilized to edit the survey accordingly. The above process ensured that the survey was easy to understand, served its intended purpose and had face validity.

Data Analysis

Data analysis was conducted using IBM SPSS Statistics 20. Descriptive statistics were computed for demographic data (age; sex; ethnicity; and academic school, faculty and program) and are summarized in Table 2. Several types of statistics were used to investigate the study's purpose of assessing university students' vitamin D-related knowledge and the associations between knowledge and demographic data. To respond to the first research question, “What percentage of university students have heard of vitamin D and what do they know about it, its sources, recommended quantity and health effects?” the frequencies and percentages of various aspects of vitamin D knowledge were calculated. The results are summarized in Table 2 - Table 7 of the Results section. The percentage of students who gained their vitamin D knowledge from each of the informational origins was calculated to respond to the research question, “From where do university students get vitamin D knowledge?” The results are summarized in Table 3. Furthermore, the relationship between knowledge origin and knowledge accuracy was investigated by correlating overall knowledge score with the corresponding knowledge origin. In addition, the relationship between demographic characteristics and knowledge score was investigated, in a correlational design, to find which relationships were significant. To further investigate the significant relationships found, a one-way ANOVA was conducted between knowledge score and age groups, ethnicity, academic faculty, academic program and amount of vitamin D taken.

Chapter 4

Results

Descriptive Statistics

In total, email invitations were sent out to 30,051students and approximately 4% of this sample participated in the survey. Of the1, 088 undergraduate students that participated in the study, 217 specified they were male and 777 were specified they were female. The remaining 94 students did not specify gender. Participants were between the ages of 17 and 66 years (*M* = 21.6, *SD* = 6.4), and varied in ethnicity. Approximately 74% of the sample self-identified as White (N = 738), 17% as Asian (N = 171), 4% as Middle Eastern (N =38), 2% as Black (N = 18), 1.5% as Latino (N = 16) and 1% as Native (N = 10). In addition, 0.3% of participants specified they were of European ethnicity (N = 3). Academically speaking, there was a range of participants from several areas of study. Of the 943 participants that identified their academic faculty, the majority were enrolled in Social Sciences (33.4%), Health Sciences (23.4%), and Natural Sciences (17.6%) programs. A summary of participant descriptive statistics can be found in Table 2.

Vitamin D and Knowledge

Of the 1,085 people who answered the first question, 1,078 (99%) had heard of vitamin D. The majority of participants had heard of vitamin D from family (63%), followed by school (53%), and/or television (40%). The origin of vitamin D knowledge results are summarized in Table 3.

Vitamin D source knowledge. Although 5% of participants indicated that they did not know where vitamin D came from, 91% correctly identified the sun as a vitamin D source. Milk/ dairy was also correctly identified as a vitamin D source by 40% of the participants, as were vitamin supplements (74%), fatty fish (20%), select cereals (17%), cod liver oil (16%), eggs (15%) and mushrooms (7%). Although many people were able to identify at least one correct source, 45% of respondents also identified an incorrect source, such as fruits (34%) and vegetables (27%). On average, respondents scored with 25% accuracy on the vitamin D source variable. Frequencies and percentages of respondents who selected the various vitamin D sources provided are summarized in Table 4.

Vitamin D DRI knowledge. For the DRI of vitamin D, only 8% of subjects selected the correct answer (600IU), while 61% reported that they did not know and 31% selected an incorrect response. Results are summarized in Table 5.

Vitamin D and sun exposure knowledge. Approximately 14% of people correctly identified 10-60 minutes in the sun per week as the average amount of time needed for a fair-skinned individual to produce the recommended amount of vitamin D, while 27% reported that they did not know and 59% selected an incorrect response. As for non-fair-skinned people, 38% of respondents correctly identified the time necessary to produce enough vitamin D through sun exposure (1-6 hours/ week), while 35% reported they did not know and 27% selected an incorrect response. Distribution of responses presented in Table 5.

Vitamin D factors knowledge. With regard to factors that may decrease the amount of vitamin D a person gets, the average participant scored with 34% accuracy. Season (67%), time of day (67%) and skin pigment (64%) were the top three vitamin D factors identified by participants. About 40% identified an incorrect vitamin D factor, such as smoking (17%), fatty diets (14%) and wind (4%). All the factors that can influence the amount of vitamin D that people get, as well as the frequency and percentage of participants that selected each factor, are summarized in Table 6.

Vitamin D insufficiency rates knowledge. About 50% of participants correctly identified that approximately 25% of Canadians are vitamin D insufficient, while the remaining 50% selected an incorrect response or reported they did not know the answer.

Vitamin D health benefits knowledge. With regard to health effects of vitamin D, participants scored with 23% accuracy. About 50% of subjects identified that vitamin D supported bone health and 47% identified that vitamin D assisted with calcium absorption. Additionally, 42% selected improved immune functioning, 33% identified prevention of osteoporosis and 27% identified prevention of general disease as health effects related to vitamin D. Less than a quarter of participants correctly identified that vitamin D is associated with prevention of rickets (21%), prevention of cancer (21%), cognitive health (20%), pregnancy/ breastfeeding support (18%), cardiovascular health (14%) and prevention of diabetes (7%). Approximately 19% of subjects admitted that they did not know what health effects vitamin D helped with and many people selected incorrect responses. Results are summarized in Table 7.

Table 2

Demographic Characteristics of Survey Participants

Characteristic	N	%	Mean	S.D	Range	Min	Max
Age (years)	991		21.64	6.43	49	17	66
17-21	742	75					
22-26	161	16					
27-31	27	3					
32-36	17	2					
37-41	9	1					
42+	35	4					
Gender	994						
Male	217	22					
Female	777	78					
Ethnicity	994						
White	738	74					
Asian/ Indian	171	17					
Middle Eastern	38	4					
Black	18	2					
Latino	16	2					
Native	10	1					
European	3	<1					
Academic School	971						
Main	778	80					
King’s	94	10					
Brescia	66	7					
Huron	33	3					
Academic Faculty	943						
Science	166	18					
Social Science	315	33					
Health Science	221	23					
Business	19	2					
Arts	95	10					
Info/Media Std.	23	2					
Engineering	36	4					
Music	22	2					
Theology	4	<1					
Med. Science	42	5					

Note. 1088 people took the survey but some people did not answer all questions, therefore percentages were calculated based on the number of people that answered the question. All percentages rounded to nearest whole number.

Table 3

Vitamin D Knowledge and Knowledge Origin

Heard of Vitamin D	Frequency (N)	Percentage (%)
Yes	1078	99
No	7	1
Total	1085	100

Knowledge Origin	Frequency (N)	Percentage (%)
Physician	348	32
Health Professional	146	13
School	583	53
Newspaper	154	14
Family	686	63
Friend	353	32
Television	435	40
Radio	115	11
Poster	76	7
Magazine	253	23
Book	204	19
Don't Know	154	14
Other	56	5
Web Research	22	22
Documentaries	1	<1
Fortified Food Ads	2	<1
Grocery Store/ Food Labels	14	1
Pharmaceutical Literature	1	<1
Tanning Salons	7	<1
Common Knowledge	4	<1
Work	1	<1
Vitamin Bottles	4	<1
Total	1085	

Note. Participants were able to pick multiple knowledge origins therefore percentages do not add up to 100%. All percentages rounded to nearest whole number.

Table 4

Distribution of Responses for Knowledge of Vitamin D Sources

Responses	Frequency (N)	Percentage (%)
I Don't Know	49	5
Sun**	987	91
Milk**	437	40
Cod Liver Oil**	171	16
Eggs**	167	15
Select Cereals**	185	17
Vitamin Supplements**	809	74
Fatty Fish**	217	20
Mushrooms**	76	7
Chicken	53	5
Nuts	124	11
Air	4	<1
Vegetables	297	27
Water	12	1
Fruits	368	34
Other	12	1
Fortified Foods***	9	<1
Citrus	1	<1
In Body	1	<1
Seals	1	<1

Note. Participants were able to select multiple answers. Percentages are rounded to nearest whole number. **Indicates correct answers. ***Indicates correct answer provided by participant.

Vitamin D Knowledge Score Associations

Analyses demonstrate associations between the vitamin D knowledge score calculated from the vitamin D knowledge survey and several other variables investigated. Significant relationships were found between aspects of demographic characteristics, knowledge origin and vitamin D intake, as described below.

Vitamin D knowledge score and demographics. Analysis indicate a significant association between knowledge score and several demographic variables. There was a significant relationship between knowledge score and age, age group, ethnicity, academic faculty, and academic program, but not gender or academic school (campus). In correlational analysis, age was related to knowledge score, $r(989) = .14$, $p < .01$, indicating that older students scored better on aspects of vitamin D knowledge. Demographic associations were analyzed by running a one-way analysis of variance (UNIANOVA) between knowledge score and each of the significantly related variables. Results suggest that there is a significant difference between age groups on the knowledge score, $F(4, 983)= 4.040$, $p=.003$, partial eta-square=.016. Age groups were broken up in two different ways for analysis. The first age group categorizations (groups A) were broken up around the mean for analysis of similar group sizes. Although group sizes were not equal, Levene's test for homogeneity of variances was non-significant therefore we can assume equal variance. Subjects 18 years and younger (24%) were labelled group 1a. Group 2a consisted of those aged 19 (18%); group 3a included those aged 20 (16%); group 4a consisted of those aged 21 (17%) and; group 5a consisted of those aged 22 and older (25%). Tukeys's HSD indicates that there was a significant difference between group 1a (ages 18 and under) and group 5a (ages 22 and up).

There was also a significant difference between group 3a and group 5a. The direction of the difference indicates that group 5a knew significantly more about vitamin D than group 1a or 3a. There was no significant difference found between group 2a or group 4a and any of the other age groups. For further analysis by age, age groups were also assessed more specifically around the target age range of the current study. The second categorization of age groups (group B) was centered on the target age group (20-39 years of age). About 55% of the sample, who reported their age, fell into the target age range. The target age group was divided into two even parts for analysis. Subjects under the age of 20 years (42%) were labelled group 1b. Group 2b consisted of those aged 20-29 (52%); group 3b included those aged 30-39 (3%) and; group 4b consisted of those aged 40 and older (4%). Although group sizes were not equal, Levene's test for homogeneity of variances was non-significant therefore we can assume equal variance. Results indicate that there was a significant difference between these age groups on knowledge score, $F(3, 987) = 5.590$, $p = .001$, partial eta-square= .017. Tukey's HSD indicates there was a significant difference in knowledge between group 1b and group 3b and 4b, such that groups 3b and 4b had more knowledge of vitamin D, $p > .05$. There was also a significant difference between group 2b and group 4b, with group 4b demonstrating more knowledge, $p > .05$.

With regard to ethnicity, results demonstrate a significant difference between ethnic groups, $F(6, 987) = 3.341$, $p = .003$, partial eta-square=.020. Tukey's HSD indicates there was a significant difference between subjects who self-identified as White and subjects who identified as Asian or Indian, such that those who indicated they were White had more vitamin D knowledge than those who identified as Asian or Indian, *p*

>.05. There were no significant differences found between any of the other ethnic groups (Latino, Native, Black, Middle Eastern, or European). Again, although group sizes were not equal, Levene's test for homogeneity of variances was non-significant therefore we can assume equal variance.

There was a significant difference between various academic faculties on knowledge score, $F(9, 933)=4.183$, $p=.000$, partial eta-square .039. Tukey's HSD reveals that the differences exist between the Social Sciences and Health Science faculties and between Social Sciences and Medical Sciences faculties, with students in Health Sciences and Medical Sciences having more knowledge than students in Social Sciences, $p < .05$. A significant difference was also noted between subjects within the Faculty of Arts and Humanities and those in the Medical Sciences faculty, with students in Medical Sciences having demonstrated more knowledge, $p < .05$. Similarly, a significant difference was found between subjects enrolled in various academic programs on the knowledge score, $F(41, 913)=2.228$, $p=.000$, partial eta-square=.091. Tukey's HSD indicates that students enrolled in the Nutrition program scored better on the vitamin D knowledge test than did students enrolled in Psychology, Business, Sociology, Management and Organizational studies, Biological, Physiological and Neurological Science, Kinesiology, General Social Science, Music programs, General Science, History, English /Literature, Math /Physics, Political Science and General Science programs, $p < .05$.

Table 5

Distribution of Responses for Knowledge on Daily Recommended Intake and Time Needed in Sun to Produce Adequate Vitamin D

Responses	Frequency (N)	Percent (%)
Daily Dose		
Don't Know	661	61
200IU	23	2
400IU	102	9
600IU**	87	8
800IU	52	5
1000IU	119	11
1500IU	17	2
2000IU	22	2
Total Responders	1083	100
Time in Sun for Fair Skin		
Did not know	293	27
Less than 10 min	111	10
1-2 hours	371	35
More than 2 hours	144	13
10-60 minutes**	156	15
Total Responders	1075	100
Time in Sun for Non-Fair Skin		
Did not know	377	35
Less than 10 min	84	8
1-6 hours**	409	38
10-20 min	170	16
More than 6 hours	44	4
Total Responders	1084	100

Note. Not all 1088 participants answered every question therefore percentages are based on those that did. **Indicates the correct response. Percentages rounded to nearest whole number.

Table 6

Distribution of Responses on Knowledge of Factors that Affect Vitamin D Levels

Vitamin D Factor	Frequency (N)	Percent (%)
Skin Pigment**	693	64
Shade**	606	56
Time of Day**	725	67
Latitude**	480	44
Season**	733	67
Age**	439	40
Pregnancy/ Breastfeeding**	180	17
Sunscreen**	468	43
Vegan Diet**	208	19
Vegetarian Diet**	161	15
Lactose Intolerance**	227	21
Dairy Allergy**	229	21
Body Mass Index**	104	10
Pollution*	260	24
UV Index**	431	40
Fatty Diets	157	14
Wind	48	4
Smoking	189	17
Other	6	1
Total	1087	100

Note. Not all 1088 participants answered every question so percentages are based on those that did. **Indicates correct response. All percentages rounded to nearest whole number.

Table 7

Distribution of Responses for Vitamin D Health Benefits

Responses	Frequency (N)	Percentage (%)
Bone Health**	540	50
Calcium Absorption**	515	47
Immune Health**	456	42
Prevents Rickets**	228	21
Pregnancy/ Breastfeeding**	191	18
Prevents Diabetes**	79	7
Cardiovascular Health**	150	14
Prevents Cancer**	231	21
Cognitive Health**	220	20
Prevents Osteoporosis**	363	33
Prevents General Disease**	296	27
Don't Know	205	19
Vision Health	170	16
Hair Growth	162	15
Skin Softness	173	16
None of the Above	5	<1
Other	34	3
Mental Health***	34	3

Note: Not all 1088 participants answered every question therefore percentages are based on those that did. All percentages rounded to the nearest whole number. **Indicates correct responses. ***Indicates some research support for response provided by participant.

Knowledge score and knowledge origin. Overall Knowledge score was significantly related to the knowledge originating from physicians, $r(1085) = .11$, $p < .01$, and other health professional, $r(1085) = .09$, $p < .01$, but not with any other knowledge origins.

Knowledge score and vitamin D usage. Of the 998 subjects who answered the question on vitamin D usage, the majority of respondents did not take vitamin D supplements (N=659). Several participants that stated they did not take vitamin D further mentioned that they got enough vitamin D from their orange juice, milk and milk substitutes or through their diets, although this information was not requested. There were 155 subjects who reported they "only take a multivitamin." For the 91 participants who reportedly took vitamin D supplements, 44 people said they took 1000IU, 16 subjects took 2000IU, 15 took 400IU, 9 took 800IU, 5 took 5000IU and 2 subjects reported they took 600IU daily. Frequencies and percentages for vitamin D usage are reported in Table 8. Approximately 23% (N = 21) of the people who took vitamin D supplements further indicated that they did not do so regularly. Several subjects cited that they often "forget" to take their supplements. The remaining 93 subjects reported that they did not know if they took vitamin D. A one-way ANOVA revealed significant differences between the amount of vitamin D taken by subjects and the knowledge score variable, $F(8, 989)=5.522$, $p=.000$, partial eta-square=.043. According to Tukey's HSD, people who reported that they took 1000 or 2000IU of vitamin D scored significantly higher on the vitamin D knowledge test than did those who do not take vitamin D, indicating that they had more knowledge of vitamin D, $p < .05$

Table 8

Vitamin D Taken Daily by Participants

Responses	Frequency (N)	Percent (%)
I Don't Know	93	9
I Don't Take Vitamin D	659	66
I Only Take a Multivitamin	155	16
I Take:		
400 IU	15	2
600 IU	2	<1
800 IU	9	1
1000 IU	44	4
2000 IU	16	2
5000 IU	5	1
Total	998	100

Note. Not all 1088 participants answered each question therefore percentages are based on those that did. All percentages rounded to nearest whole number.

Chapter 5

Discussion

Vitamin D Knowledge

The purpose of the current project was to gain a baseline assessment of university students' vitamin D-related knowledge to inform the development of health promotion programs aimed at decreasing vitamin D insufficiency. A sample of university students at a large urban Canadian school were asked about their vitamin D knowledge to gain insight into the current level of vitamin D awareness and understanding in an at-risk Canadian population. To properly assess vitamin D knowledge, the following questions were posed:

1. What percentage of university students have heard of vitamin D and what do they know about it, its sources, recommended quantity, and health effects?
2. From where do university students get vitamin D knowledge and what is the association between knowledge origin and knowledge accuracy?

In response to the first research question, this sample of Canadian University students exemplified a higher rate of familiarity with the term "vitamin D" than did previous studies conducted in Australia (Vu et al., 2010) and China (Kung & Lee, 2006), though similar evidence of a knowledge deficit was observed when it came to information about vitamin D, such as its' sources, recommended intake and associated health effects. It is possible that there was a response bias in that many of those who did not have knowledge of vitamin D may have decided not to take the survey, therefore a higher percentage of students may not have heard of vitamin D. In line with prediction, the current study found low rates of vitamin D knowledge. Overall knowledge score average was 27%, thus highlighting the need for increasing awareness and educating the public about vitamin D.

Vitamin D source knowledge. Overall, participants scored with 25% accuracy when identifying sources of vitamin D. In comparison to previous studies (i.e., Kung and Lee, 2006; Vu et al., 2010), a higher proportion of subjects in the current study correctly identified the sun (91% vs. 83% and 23% respectively) and vitamin supplements (74% vs. 69% and 0.9% respectively) as sources of vitamin D. In general, participants in the current study were better able to correctly identify sources of vitamin D compared to those in the study by Kung and Lee (2006). In the current study, 40% of subjects identified milk/dairy as a source of vitamin D, while only 9% of those in the 2006 study did. Similarly, at least 15% of participants in the current study identified cod liver oil and eggs as a source of vitamin D while 0.5% of those in the 2006 study did. Further comparison of the percentage of participants that correctly identified the other vitamin D sources in the Vu and Colleagues (2010) study is not possible, as they grouped sources together and only reported that 33% of subjects were able to identify at least one correct source of vitamin D.

Although the majority of participants in the current study were able to identify the sun and vitamin D supplements as sources of vitamin D, a minority of subjects were able to identify accurate food sources and almost half identified an incorrect source of vitamin D. These findings are problematic for the surveyed population, because the sources of vitamin D that were least identified are the sources that more Canadians rely on more consistently for vitamin D (i.e., diet based vitamin D). The reason for this is because the high latitude of Canada makes adequate vitamin D inaccessible through the sun for about half the year (Holick, 2007a; Mithal et al., 2009; Roth et al., 2005; Rucker et al., 2002) and only about 11% of the sample reported taking vitamin D supplements. Therefore the majority of surveyed Canadians typically must rely more heavily and more consistently on the sources of vitamin D that they least recognize (food intake year round verses the sun and supplements). In fact, Canadians only get about 250IU of vitamin D a day through their diets (about 42% of the Daily Recommended Intake; Vatanparast et al., 2010), which is not sufficient. The Health Belief Model (Hochbaum, 1958; Rosenstock, 1966) and Expanded Health Belief Model (Burns, 1992) assume that people will perform a health promoting behaviour (such as vitamin intake), if they perceive a serious health threat, believe that the health behaviour will reduce the health threat, perceive minimal barriers and believe they can effectively execute the health behaviour (i.e., have high self-efficacy to engage in the behaviour). Accordingly, if Canadians are aware of the importance of taking in vitamin D to improve their health, but do not know where to get vitamin D (a barrier that reduces feelings of self-efficacy), they are less likely to seek out these sources and engage in the desired health behaviour. Perhaps the noted lack of vitamin D knowledge contributes to the high rates of vitamin D insufficiency that Canadians have demonstrated to date. Indeed, a study investigating factors associated with the intention to use vitamin D, found that knowledge and awareness of the health benefits of vitamin D and increased self-efficacy were tied to the intention to use vitamin D (Engles, van Assema, Dorant, & Lechner, 2001). Undoubtedly, the level of concern one has with regards to their health, may be a contributing factor. It is hoped that most people are concerned with their personal health.

Knowledge of recommended vitamin D. With regard to the amount of vitamin D recommended daily, only 8% of respondents correctly identified the RDA of vitamin D, and only 14% correctly identified how much time a fair-skinned individual would need to spend in the sun to produce enough vitamin D. Similar to previous studies (e.g., Vu et al., 2010), people often thought they required more time in the sun to produce adequate vitamin D. Interestingly, several participants indicated that they got enough vitamin D through drinking milk, milk substitutes, orange juice, and through eating healthy. As stated previously, evidence demonstrates that the majority of Canadians do not get enough vitamin D through their daily diets (Vatanparast et al., 2010), thus highlighting the need to increase awareness on the RDA and appropriate methods of achieving the RDA.

Knowledge of vitamin D health effects. In terms of vitamin D associated health effects, participants scored with 23% accuracy. About half the participants correctly identified bone health, the strongest vitamin D-related health effect, while 76% of the sample in the study by Vu and colleagues and 18% of the sample from Kung and Lee (2006) correctly identified bone health as associated with vitamin D. In general, subjects in the current study were less knowledgeable than those in the study by Vu and colleagues and more knowledgeable than those in the study by Kung and Lee, in terms of vitamin D health effects. Given that the longstanding positive effect vitamin D has on the bones is better recognized and agreed upon by professionals, it is not surprising that subjects were most knowledgeable of the association between vitamin D and bone health, including calcium absorption (47%), and prevention of osteoporosis (33%). Subjects were also fairly knowledgeable on the association between vitamin D and immune health (42%). However, they were less knowledgeable on the association between vitamin D and cardiovascular health, cognitive health, healthy pregnancy, and the prevention of cancer, and diabetes, likely because these associations have been more recently identified (i.e., within the last several years) and have not necessarily been agreed on by all professionals. Considering researchers remain challenged to build consensus about the full role vitamin D plays in non-bone related health issues (e.g., Bischoff-Ferrari et al., 2009b; Holick, 2007a; Hypponen et al., 2001; Simpson, 2011; Simpson et al., 2010; Smolders et al., 2008; Vieth, 2004;), it is not surprising that people are less knowledgeable of these associations. Given that consensus in many areas of health is less than unanimous (for example, how much water to drink, which diet is best or what vitamins to take), it seems the positive effects of vitamin D need to be made more aware, as there appears to be no health related disadvantage to increasing vitamin D intake to the RDA and/or up to 1000IU (Holick, 2007a; Vieth, 1999).

Factors affecting vitamin D levels. Participants scored relatively well (34% accuracy) in comparison to previous studies, when identifying factors that are generally related to decreased vitamin D. Many of the factors that were identified with increased frequency involved the relationship between vitamin D and the sun, such as skin pigment, shade, time of day, use of sunscreen, latitude, season and UV index. They were less knowledgeable about the effect that factors such as BMI, pregnancy, and restricted diets, can have on vitamin D levels, making these factors especially important to address in any health promotion program aimed at decreasing vitamin D deficiency.

In terms of accuracy, participants in the current study scored better on aspects of vitamin D knowledge that reflected insufficiency rates (50%), time required in the sun to produce enough vitamin D for non-fair skinned individuals (38%) and factors that influence vitamin D levels (34%). Subjects scored with less than 30% accuracy on identifying vitamin D sources (25%), associated health effects (23%), time needed in the sun by fair-skinned individuals (14%) and daily recommended dosage (8%). Arguably, knowledge of where to get adequate amounts of vitamin D and the reasons thereof (to improve various aspects of health) are the more useful areas of vitamin D knowledge, in terms of increasing intake (in accordance with HBM). As such, higher rates of knowledge in these areas would be key areas for concern in any health promotion campaign.

Vitamin D knowledge origin. The discussion below is in response to the second research question. As predicted, students tended to get their vitamin D knowledge from family (63%), school (53%), and television (40%), while the majority of those in the study by Vu and Colleagues (2010) got their information from the media (44%). Students who got their vitamin D-related information from physicians and other health professionals scored better on the knowledge test, as hypothesized. It seems reasonable that students who received information about vitamin D from various health professionals would receive more accurate knowledge and thus score better on the knowledge test; however, only 32% of subjects reportedly received their vitamin D knowledge from physicians and only 14% from other health professionals. In fact, research has demonstrated that many health professionals are not completely aware of the benefits of vitamin D (Khalsa, 2009) and other research evidence has reinforced the need for further educating health care professionals so that they may effectively transfer this knowledge to the public (Brand et al., 2008). Furthermore, evidence supports the importance of physician mediated knowledge translation, as people report higher rates of intention to use vitamin D when they have been informed of the benefits via physician (Engles et al., 2001). Indeed, future health promotion programs should aim to increase the amount of vitamin D-related knowledge that all health professionals provide to their clients, as the current level of knowledge in the health professions may be less than ideal (Brand et al., 2008; Khalsa, 2009; Zipitis, Elazabi, & Samanta, 2011).

Vitamin D knowledge and demographic associations. The observed association between age and vitamin D knowledge score in the current study is not surprising, as previous studies have also found higher rates of knowledge with age (e.g., Vu et al., 2010). Popular culture would also dictate that “knowledge comes with age;” however, there may be additional factors involved in this relationship when looking at the differences between and among age groups. For example, many health promotion initiatives have targeted prevention of osteoporosis through increased vitamin D intake, particularly in middle-aged women (National Institute of Health, 2012; Osteoporosis Society of Canada, 2008; Rizzoli et al., 2008; Roux et al., 2008). One of the primary strategies for prevention of osteoporosis is the use of calcium and vitamin D to build bone strength (National Institute of Health, 2012; Osteoporosis Society of Canada, 2012; Papaioannou, et al., 2010; Rizzoli et al., 2008; Roux et al., 2008); therefore, it is not surprising that that older populations would have more knowledge on these aspects of vitamin D. In fact, people 30 years of age and older scored significantly better on knowledge of vitamin D, than did those 29 and younger. Coincidentally, age

30 is when adults hit their peak bone density and many health professionals begin to recommend increased calcium and vitamin D intake (National Institute of Health, 2012). In actuality, the best defence against osteoporosis is to boost bone health prior to age 20 (National Institute of Health, 2012; Roth et al., 2005). Unfortunately, results of the current study indicate that people in this age rage are the ones least knowledgeable about the benefits of using vitamin D to build bone strength and they are also in the age range of those at increased risk of vitamin D deficiency (Langlois et al., 2010; Whiting et al, 2011) These realizations thus highlight the need to further educate young adults, as they are at a critical stage of bone development, most at risk of vitamin D deficiency and lacking knowledge of vitamin D.

Interestingly, there was an observed difference in knowledge score between those who identified as White and those who identified as Asian or Indian. Although explanation for this difference is not clear, a similar study conducted in China did find lower rates of vitamin D knowledge than this particular study (Kung & Lee, 2006). There is some evidence that Asians (including people of Indian ethnicity) may have poorer musculoskeletal health, including increased risk of fracture (Darling et al., 2013), increased prevalence of some types of osteoporosis (Khandewal, Chandra, & Lo, 2012) decreased calcium intake and greater prevalence of vitamin D deficiency (Harinarayan, 2005) when compared to similar Caucasians. As people with more pigmented skin (e.g., Asians or Indians) require longer exposure in the sun to produce adequate amounts of vitamin D and they seem to have less knowledge about vitamin D and a potentially increased risk of poor bone health, this specific sub-population may require additional focus in any health promotion campaign aimed at increasing vitamin D knowledge and decreasing deficiency rates. It is possible that differences in knowledge between other ethnic groups were simply indistinguishable due to small sample size, as fewer than 40 subjects from each of the other ethnic groups participated, or that the observed difference is spurious.

In terms of academic program differences in knowledge score, it is not surprising that students in the Health and Medical Sciences scored better than those in Social Sciences and/or the Arts, as students in these faculties are more likely to be exposed to topics related to vitamin D, such as on nutrition, physiology and biology. In fact, students enrolled in the Nutrition program scored better on the knowledge test than did the majority of students enrolled in all other programs. According to enrollment data from the host university (Western University, 2012) and the demographic data collected in the current study, almost all students enrolled in the Nutrition program took the vitamin D survey. It is not surprising that students in the Nutrition program would have increased interest in a survey of nutritional relevance; however, it is important to acknowledge that the increased response rate from those in the Nutrition program may have skewed the knowledge score, as students in the Nutrition program scored significantly better than those in other programs. Therefore, general knowledge of vitamin D may be lower among the general population of Western University undergraduate students than results of the survey would suggest.

Vitamin D knowledge and intake. Given the high rates of vitamin D deficiency, and the inadequate vitamin D consumption reported by Canadians along with the difficulty this sample of Canadian undergraduate students had in recognizing sources of vitamin D, it is alarming to find such low rates of vitamin D supplement usage. Only 11%

of this sample reported consuming vitamin D supplements, yet many researchers advocate for all adults to take vitamin D supplements, especially in the winter (Dawson-Hughes, 2005; Holick, 2007a; Papaioannou, et al., 2010; Osteoporosis Society of Canada, 2012). As previously stated, people tend to incorrectly assume they are getting enough vitamin D. On the positive side, vitamin D knowledge and vitamin D supplement use were associated. Although causality cannot be demonstrated from the analysis conducted, it is reasonable to infer that people who know more about vitamin D and its associated health benefits are more likely to increase their vitamin D intake through the use of supplements. As such, this lends support for the theory that increasing knowledge and awareness about vitamin D may increase supplement usage. Undoubtedly, knowledge of health issues and preventive health behaviour are important factors that can alter an individual's motivation to adopt a health behaviour, which is why knowledge is such a critical component of many health promotion program planning models (Burns, 1992; Hochbaum, 1958; McKenzie et al., 2009; Rosenstock, 1966).

Limitations of the Present Study

There are several possible limitations to the current study. First, the survey used was developed primarily for the purpose of the current study and has therefore not been used and validated beyond the context of the current study. In addition, although relatively large in numbers, the sample was derived from only one university and therefore may not be generalizable to all Canadian student populations. Furthermore, the sample was very homogenous in terms of age and ethnicity therefore any conclusions drawn must be interpreted with caution. In addition, possible response bias may have influenced the results by potentially increasing the baseline knowledge of students due to high response rate of students in Nutrition program and potentially from those with a pre-existing knowledge base or interest in vitamin D. Conversely, actual vitamin D knowledge may have been minimized by deducting equally-weighted points for incorrect responses (valid distractors) in the calculation of the knowledge score. Despite these limitations, important information about vitamin D and university students has been found.

Conclusions and Future Prospects

As a whole, the current study added to the research on vitamin D knowledge by assessing the knowledge rates of a sample of Canadian undergraduate university students, and included criteria that had not previously been tested, such as knowledge of the DRI. Despite recent attention regarding vitamin D DRI increases and vitamin D inadequacy throughout the Canadian population has received, considerable deficits in knowledge of vitamin D, its sources, required intake, factors affecting vitamin D levels and its associated health benefits remain high among the current study's sample of university students. Results of the current study are largely consistent with those conducted in other countries when it comes to identifying a knowledge deficit. Certainly, there is a strong need for health promotion programming aimed at increasing vitamin D knowledge rates and providing key information that will help inform and encourage people to adopt health-related behaviours that will decrease rates of insufficiency, especially in at-risk groups of Canadians. In addition, programs must take into consideration the origins of knowledge that people trust and that are associated with increased knowledge, such as practitioners. Future programming must take into consideration the evidenced gaps in knowledge and consequently, design effective educational campaigns targeted to specific populations, as a first step to increasing awareness and, eventually, personal responsibility, adequate intake, and thereby improving overall health.

References

Alemzadeh, R., Kichler, J., Babar, G., & Calhoun, M. (2008). Hypovitaminosis D in obese children and adolescents: Relationship with adiposity, insulin sensitivity, ethnicity, and season. *Metabolism, 57*(2), 183-191. doi:10.1016/j.metabol.2007.08.023.

Alvarez, R. M., & VanBeselaere, C. (2005). Web-Based survey. *Encyclopedia of Social Measurement, 3,* 955-962.

Anderson, L. N., Cotterchio, M., Vieth, R., & Knight, J. A. (2010). Vitamin D and calcium intakes and breast cancer risk in pre- and postmenopausal women. *American Journal of Clinical Nutrition, 91*(6), 1699-1707. doi: 10.3945/ajcn.2009.28869.

Annweiler, C., Allali, G., Allain, P., Bridenbaugh, S., Schott, A. M., Kressig, R. W., & Beauchet, O. (2009). Vitamin D and cognitive performance in adults: A systematic review. *European Journal of Neurology,16*(10), 1083-1089. doi:10.1111/j.1468-1331.2009.02755.x

Annweiler, C., Schott, A. M., Rolland, Y., Blain, H., Herrmann, F. R., & Beauchet, O. (2010). Dietary intake of vitamin D and cognition in older women: A large population-based study. *Neurology, 75*(20), 1810-1816. doi:10.1212/WNL.0b013e3181fd6352

Baer, A., Saroiu, S., & Koutsky, L. A. (2002). Obtaining sensitive data through the web: An example of design and methods. *Epidemiology, 13*(6), 640-645.

Bischoff-Ferrari, H. A., Dawson-Hughes, B., Staehelin, H. B.,Orav, J. E., Stuck, A. E., Theiler, R., . . . Henschkowski, J. (2009a). Fall prevention with supplemental and active forms of vitamin D: A meta-analysis of randomised controlled trials. *British*

Medical Journal, 339, doi: 10.1136/bmj.b3692.

Bischoff-Ferrari, H. A., Giovannucci, E., Willett, W. C., Dietrich, T., & Dawson-Hughes, B. (2006). Estimation of optimal serum concentrations of 25-hydroxyvitamin D for multiple health outcomes. *American Journal of Clinical Nutrition*, *84*(1), 18-28.

Bischoff-Ferrari, H. A., Willett, W. C., Wong, J. B., Stuck, A. E., Staehelin, H. B., Orav, E. J., . . . Henschkowski, J. (2009b). Prevention of nonvertebral fractures with oral vitamin D and dose dependency: A meta-analysis of randomized controlled trials. *Archives of Internal Medicine, 169*(6)*,* 551-561. doi: 10.1001/archinternmed.2008.600.

Blank, S., Scanlon, K. S., Sinks, T. H., Lett, S., & Falk, H. (1995). An outbreak of hypervitaminosis D associated with the overfortification of milk from a home-delivery dairy. *American Journal of Public Health, 85*(5)*,* 656–659.

Brand, C., Hodan, Y., Abi, D., Couch, A., Vindigini, A., Wark, J. (2008) Vitamin D deficiency: A study of community beliefs among dark skinned and veiled people. *International Journal of Rheumatic Disease, 11*(1)*,* 15-23. doi: 10.1111/j.1756-185X.2008.00323.x

Brenner, D. R., Arora, P., Garcia-Bailo, B., Wolever, T. M., Morrison, H., El-Sohemy, A., . . . Badawi, A. (2011). Plasma vitamin D levels and risk of metabolic syndrome in Canadians. *Clinical Investigative Medicine, 34*(6)*,* E377-E384. http://dx.doi.org/10.5888/pcd10.120230

Burns, A. C. (1992). The expanded health belief model as a basis for enlightened preventive health care practice and research*. Journal of Health Care Marketing,12*(3)*,* 32-45.

Calvo, M. S., Whiting, S. J., & Barton, C. N. (2004). Vitamin D fortification in the United States and Canada: Current status and data needs. *American Journal of Clinical Nutrition, 80*(Suppl. 6), 1710S–1716S.

Camargo, C. J., Rifas-Shiman, S., Litonjua, A. A., Rich-Edwards, J. W., Weiss, S. T., Gold, D. R., . . . Gillman, M. W. (2007). Maternal intake of vitamin D during pregnancy and risk of recurrent wheeze at 3 y of age. *American Journal of Clinical Nutrition, 85,* 788-95.

Canadian Paediatric Society. (2002). First Nations and Inuit Health Committee. Vitamin D supplementation in northern Native communities. *Paediatric Child Health, 7*, 459-463.

Canadian Paediatric Society. (2007). First Nations, Inuit and Métis Health Committee Vitamin D supplementation: Recommendations for Canadian mothers and Infants. *Paediatric Child Health,12*(7), 583-589.

Centers for Disease Control and Prevention. (2008). National Report on Biochemical Indicators of Diet and Nutrition in the U.S. Population 1999-2002. Retrieved from: http://www.cdc.gov/nutritionreport/part_2bhtml

Christie, F. T., & Mason, L. (2011). Knowledge, attitude and practice regarding vitamin D deficiency among female students in Saudi Arabia: A qualitative exploration. *International Journal of Rheumatic Disease, 14*(3), e22-e29. doi: 10.1111/j.1756-185X.2011.01624.x

Darling, A. L., Hakim, O. A., Horton, K., Gibbs, M. A., Cui, L., Berry, J. L., Lanham, S. A., & Hart, K.H. (2013). Adaptations in tibial cortical thickness and total volumetric bone density in postmenopausal South Asian women with small bone size. *Bone,* *55*(1), 36-43. doi: 10.1016/j.bone.2013.03.006

Dawson-Hughes, B., Heaney, R. P., Holick, M. F., Lips, P., Meunier, P. J., & Vieth, R. (2005). Estimates of optimal vitamin D status. *Osteoporosis International,16*(7), 713-716.

Dean, A. J., Bellgrove, M. A., Hal, T., Phan, W. M., Eyles, D. W., Kvaskoff, D., McGrath, J. J. (2011). Effects of vitamin D supplementation on cognitive and emotional functioning in young adults--a randomised controlled trial. Public Library *of Science One, 6*(11), e25966. doi:10.1371/journal.pone.0025966

DeLuca, H. F. (1988). The vitamin D story: A collaborative effort of basic science and clinical medicine. *The Journal of the Federation of American Societies for Experimental Biology*, *2*(3), 224-236.

DeLuca, H. F. (2004). Overview of general physiologic features and functions of vitamin D. *American Journal of Clinical Nutrition, 80*(Suppl. 6), 1689S-1696S.

Deshpande, S., Basil, M. D., & Basil, D. Z. (2009). Factors influencing healthy eating among college students: An application of the health belief model. *Health Marketing Quarterly, 26*(2), 145-164. doi:10.1080/07359680802619834

Dinger, M. K., & Waigandt, A. (1997). Dietary intake and physical activity behaviors of male and female college students. *American Journal of Health Promotion, 11*(5), 360- 362.

Di Rosa, M., Malaguarnera, M., Nicoletti, F., & Malaguarnera, L. (2011). Vitamin D3: A helpful immuno-modulator. *Immunology, 134*(2) 123–139. doi: 10.1111/j.1365-2567.2011.03482.x

Dixon, T., Mitchell, P., Beringer, T., Gallacher, S., Moniz, C., Patel, S., . . . Ryan. P.

(2006). An overview of the prevalence of 25-hydroxy-vitamin D inadequacy amongst elderly patients with or without fragility fracture in the United Kingdom. *Current Medical Research and Opinion, 22*(2)*,* 405-415.

Dobnig, H., Pilz, S., Scharnagl, H., Renner, W., Seelhorst, U., Wellnitz, B., . . . Maerz, W. (2008). Independent association of low serum 25-hydroxyvitamin D and 1,25-dihydroxyvitamin D levels with all-cause and cardiovascular mortality. *Archives of Internal Medicine, 168*(12), 1340-1349. doi: 10.1001/archinte.168.12.1340

Edmonds, E. T. (2009). Osteoporosis knowledge, beliefs, and behaviors of college students: Utilization of the health belief model. *Dissertation Abstracts International Section A: Humanities and Social Science, 70*, 2908.

Engles, Y., van Assema, P., Dorant, E., & Lechner, L. (2001). Factors associated with the intention to use vitamin D supplements; Quantitative study among a sample of elderly people in a medium-sized town in the Netherlands. *Journal of Nutritional Education, 33*(3)*,* 134-142.

The EURODIAB Study. (1999). Vitamin D supplement in early childhood and risk for type I (insulin-dependent) diabetes mellitus. The EURODIAB Substudy 2 Study Group. *Diabetologia, 42*(1)*,* 51-54. doi: 10.1007/s001250051112

Forman, J. P., Curhan, G. C., & Taylor, E. N. (2008). Plasma 25-hydroxyvitamin D levels and risk of incident hypertension among young women. Hypertension, *52*(5), 828-832. doi: 10.1161/HYPERTENSIONAHA.108.117630

Forman, J. P., Giovannucci, E., Holmes, M. D., Bischoff-Ferrari, H. A., Tworoger, S. S., Willett, W. C., & Curhan, G. C. (2007). Plasma 25-hydroxyvitamin D levels and risk of incident hypertension. *Hypertension, 49*(5)*,* 1063-1069.

Friericks, M &, Valluri, A. (2011). Vitamin D deficiency as a risk factor for allergic disorders and immune mechanisms. *Allergy and Asthma Proceedings, 32*(6), 438-444. doi: 10.2500/aap.2011.32.3485

Gammage, K. L. & Klentrou, P. (2011). Predicting osteoporosis prevention behaviors: Health beliefs and knowledge. *American Journal or Health Behavior, 35,* 371-382.

Garanty-Bogacka, B., Syrenicz, M., Goral, J., Krupa, B., Syrenicz, J., Walczak, M., & Syrenicz, A. (2011). Serum 25-hydroxyvitamin D (25-OH-D) in obese adolescents. *Endokrynologia Polska, 62*(6)*,* 506-511.

Genuis, S. J., Schwalfenberg, G. K., Hiltz, M. N., & Vaselenak, S. A. (2009). Vitamin D status of clinical practice populations at higher latitudes: Analysis and applications. *International Journal of Environmental Research and Public Health, 6*(1)*,* 151-73. doi: 10.3390/ijerph6010151

Ginde, A. T., Liu, M. C., & Camargo, C. A. Jr. (2009). Demographic differences and trends of vitamin D insufficiency in the US population, 1988-2004. *Archives of Internal Medicine, 169*(6)*,* 626-632. doi: 10.1001/archinternmed.2008.604

Giovannucci, E., Liu, Y., Hollis, B. W., & Rimm, E. B. (2008). 25-hydroxyvitamin D and risk of myocardial infarction in men: A prospective study. *Archives of Internal Medicine, 168*(11)*,* 1174-1180. doi: 10.1001/archinte.168.11.1174.

Gorham, E. D., Garland, C. F., Garland, F. C., Grant, W. B., Mohr, S. B., Lipkin, M., . . . Holick, M. F. (2007). Optimal vitamin D status for colorectal cancer prevention: A quantitative meta analysis. *American Journal of Preventative Medicine, 32*(3), 210-216.

Gopinath, K., & Danda, D. (2011). Supplementation of 1,25 dihydroxy vitamin D3 in patients with treatment naive early rheumatoid arthritis: A randomised controlled trial. *International Journal of Rheumatic Disease, 14*(11), 332-339. doi: 10.1111/j.1756-185X.2011.01684.x.

Gozdzik, A., Barta, J. L., Wu, C., Wagner, D., Cole, D. E., Vieth, R., . . . Parra, E. J. (2008). Low wintertime vitamin D levels in a sample of healthy young adults of diverse ancestry living in the Toronto area: Associations with vitamin D intake and skin pigmentation. *BMC Public Health,* 8, 336. doi: 10.1186/1471-2458-8-336.

Green, L. W., & Kreuter, M. W. (1999). *Health promotion planning: An educational and ecological approach* (3rd ed.). Mountain View, CA: Mayfield.

Green, L. W., & Kreuter, M. W. (2005). *Health program planning: An educational and ecological approach* (4th ed.). New York, NY: McGraw-Hill.

Haase, A., Steptoe, A., Sallis, J. F., & Wardlem, J. (2004). Leisure time physical activity in university students from 23 countries: Associations with health beliefs, risk awareness, and national economic development. *Preventive Medicine, 39*(1), 182-190.

Hall, L. M., Kimlin, M. G., Aronov P. A., Hammock, B. D., Slusser, J. R., Woodhouse, L. R. & Stephensen, C.B. (2010). Vitamin D intake needed to maintain target serum 25-hydroxyvitamin D concentrations in participants with low sun exposure and dark skin pigmentation is substantially higher than current recommendations. *Journal of Nutrition, 140*(3), 542–550. doi: 10.3945/jn.109.115253

Hallett, J., Howat, P. M., Maycock, B. R., McManus, A., Kypri, K.,& Dhaliwal, S. S. (2012). Undergraduate student drinking and related harms at an Australian university: Web-based survey of a large random sample. *BMC Public Health,* *12,* 37. doi:10.1186/1471-2458-12-37

Harinarayan, C. V. (2005). Prevalence of vitamin D insufficiency in postmenopausal south Indian women. *Osteoporosis International, 16*(4)*,* 397-402.

Hayden, J. (2009). Health Belief Model. In J. A. Geraci & A. L. Flagg (Eds.), *Introduction to health behavior theory* (pp. 31-44). Mississauga, ON: Jones and Bartlett Learning.

Health Canada. (2008). Health Effects of UV Radiation. Retrieved from: http://www/hc-sc.gc.ca/hl-vs/sun-sol/expos/health-uv-sante-eng.php

Health Canada (2010a). Osteoprosis Awareness Month. Retrieved from: http://www.hc-sc.gc.ca/ahc-asc/minist/messages/_2010/2010_11_01a-eng.php

Health Canada. (2010b). Vitamin D and calcium: Updated dietary reference intakes. Retrieved from: http://www.hc-sc.gc.ca/fn-an/nutrition/vitamin/vita-d-eng.php

Heaney, R. P. (2007). Bone health. *American Journal of Clinical Nutrition, 85*(Suppl. 5)*,* 300S- 303S.

Heaney, R. P., Davies, K. M., Chen, T. C., Holick, M. F., & Barger-Lux. (2003). Human serum 25-hydroxycholecalciferol response to extended oral dosing with cholecalciferol. *American Journal of Clinical Nutrition, 77*(1)*,* 204-210.

Hoang, M. T., Defina, L. F., Willis, B. L., Leoonard, D. S., Weiner, M. F., & Brown, E. S. (2011). Association between low serum 25-hydroxyvitamin d and depression in a large sample of healthy adults: the cooper center longitudinal study. *Mayo Clinical Proceedings, 86*(11)*,* 1050-1055. doi: 10.4065/mcp.2011.0208

Hochbaum, G. M. (1958). Public Participation in Medical Screening Programs: A Socio-psychological Study (DHEW Publication No. 572, Public Health Services).

Washington, DC.: U.S. Government Printing Office.

Holick, M. F. (2005). The vitamin D epidemic and its health consequences. *Journal of Nutrition, 35,* 2739S-2748S.

Holick M. F. (2006). Resurrection of vitamin D deficiency and rickets. *Journal of Clinical Investigation,116,* 2062-2072. doi:10.1172/JCI29449.

Holick, M. F. (2007a). Vitamin D deficiency*. New England Journal of Medicine,* 357, 266-281. doi: 10.1056/NEJMra070553

Holick, M. F. (2007b). Optimal vitamin D status for colorectal cancer prevention: A quantitative meta analysis*. American Journal of Preventive Medicine, 32*(3), 210-216.

Holick, M. F. & Chen, T. C. (2008). Vitamin D deficiency: A worldwide problem with health consequences. *American Journal of Clinical Nutrition, 87*(4), 1080S– 6S.

Huang, J., & Xie, Z. F. (2012). Polymorphisms in the vitamin D receptor gene and multiple sclerosis risk: A meta-analysis of case-control studies*. Journal of Neurological Science, 313*(1-2)*,* 79-85. doi: 10.1016/j.jns.2011.09.024.

Huotari, A., & Herzig, K-H. (2008). Vitamin D and living in northern latitudes-An endemic risk area for vitamin D deficiency*, International Journal of Circumpolar health, 67*, 2-3. (2-3) on site

Hypponen, E., Laara, E., Reunanen, A., Jarvelin, M. R., & Virtanen, S. M. (2001). Intake of vitamin D and risk of type 1 diabetes: A birth-cohort study. *Lancet, 353*(9292), 1500-1503.

Institute of Medicine. (2011). *Dietary Reference Intakes for Calcium and Vitamin D.* Washington, DC: National Academy Press.

Institute of Medicine. (1997). *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride.* Washington, DC: National Academy Press.

Irwin, J. D. (2004). Prevalence of university students' sufficient physical activity: A systematic review. *Perceptive Motor Skills, 98*(3 Pt 1), 927-943.

Javaid,M. K., Crozier, S. R., Harvey, N. C., Gale, C. R., Dennison, E. M., Boucher, B. J., . . . Cooper,C. (2006). Princess Anne Hospital Study Group. Maternal vitamin D status during pregnancy and childhood bone mass at age 9 years: A longitudinal study. *Lancet, 367,* 36-43. (Erratum in 2006, 367:1486).

Jones, G., Strugnell, S. A., & DeLuca, H. F. (1998). Current understanding of the molecular actions of vitamin D. *Physiological Reviews, 78*(4)*,* 1193–1231.

Katz, A., Davis, P., & Scott-Findlay, S. (2002). Ask and ye shall plan-A health needs assessment of a university population. *Canadian Journal of Public Health, 93*(1), 63-66.

Khalsa, K. (2009). The vitamin D revolution: How the power of this amazing vitamin can change your life. Hay House Inc., New York.

Khandewal, S., Chandra, M., & Lo, J. C. (2012). Clinical characteristics, bone mineral density and non-vertebral osteoporotic fracture outcomes among post-menopausal U.S. South Asian Women. *Bone, 51*(6)*,* 1025–1028. doi: 10.1016/j.bone.2012.08.118.

Köstner, K., Denzer, N., Müller, C. S., Klein, R., Tilgen, W., & Reichrath, J. (2009). The relevance of vitamin D receptor (VDR) gene polymorphisms for cancer: A review of the literature. *Anticancer Research, 29*(9)*,* 3511-3536.

Koutkia, P., Chen, T. C., Holick, M. F. (2001). Vitamin D intoxication associated with an over-the-counter supplement. *New England Journal of Medicine, 345*(1)*,* 66–67.

Kung, A. W. C. & Lee, K. (2006). Knowledge of vitamin D and perceptions and attitudes toward sunlight among Chinese middle-aged and elderly women: A population survey in Hong Kong. *BioMed Central Public Health, 6,* 226. doi:10.1186/1471-2458-6-226. Available from: http://www.biomedcentral.com/1471-2458/6/226

Kypri, K., Gallagher, S. J., & Cashell-Smith, M. L. (2004). An internet-based survey method for college student drinking research. *Drug and Alcohol Dependence, 76*, 45-53.

Langlois, K., Greene-Finestone, L., Little, J., Hidiroglou, N., & Whiting, S. (2010). *Vitamin D status of Canadians as measured in the 2007 to 2009 Canadian Health Measures Survey* (Report No. 82-00-XPE). Retrieved from Statistics Canada website: http://www.statcan.gc.ca/pub/82-003-x/82-003-x2010001-eng.htm

Li, H., Stampfer, M. J., Hollis, J. B., Mucci, L. A., Gaziano, J. M., Hunter, D., . . . Ma J. (2007). A Prospective Study of Plasma Vitamin D. Metabolites, Vitamin D Receptor Polymorphisms, and Prostate Cancer, *Public Library of Science Med*, 4(3), 0562-0571, e103. doi:10.1371/journal.pmed.0040103

Lin, J., Manson, J. E., Lee, I-M., Cook, N. R., Buring, J. E., & Zhang, S. M. (2007). Intakes of calcium and vitamin D and breast cancer risk in women. *Archives of Internal Medicine*, *167*(10), 1050-1059.

Liu, B. A., Gordon, M., Labranche, J. M., Murray, T. M., Vieth, R., & Shear, N. H. (1997). Seasonal prevalence of vitamin D deficiency in institutionalized older adults. *Journal of the American Geriatric Society, 45(5),* 598-603.

Mansbach, J. M., Ginde, A. A., & Camargo, C. A. (2009). Serum 25-hydroxyvitamin D levels among US children aged 1 to 11 years: Do children need more vitamin D? *Pediatrics, 124*(5), 1404-1410. doi: 10.1542/peds.2008-2041.

Manson, J. E., Bassuk, S. S., Lee I. M., Cook N. R., Albert M. A, Gordon D., Buring J. E. (2012). The VITamin D and OmegA-3 TriaL (VITAL): Rationale and design of a large randomized controlled trial of vitamin D and marine omega-3 fatty acid supplements for the primary prevention of cancer and cardiovascular disease. *Contemporary Clinical Trials, 33*(1), 159-171. doi: 10.1016/j.cct.2011.09.009

Mattila, C., Knekt, P., Mannisto, S., Rissanen, H., Laaksonen, M. A., Montonen, J., & Reunanen, A. (2007). Serum 25-hydroxyvitamin D concentration and subsequent risk of type 2 diabetes. *Diabetes Care, 30*(10), 2569-2570.

McCollum E. V., Simmonds, N., Becket, J. E., & Shipley, P. G. (1922). Studies on experimental rickets. XXI. An experimental demonstration of the existence of a vitamin, which promotes calcium deposition. *Journal of Biological Chemistry,* 53, 219–312.

McKenzie, J. F., Neiger, B. L., & Thackeray, R. (2009). *Planning, implementing and evaluating health promotion programs* (5th ed.). San Francisco: Pearson Benjamin Cummings.

Mehta, S., Giovannucci, E., Mugusi, F. M., Spiegelman, D., Aboud, S., Hertzmark, E., . . . Fawzi, W. W. (2010). Vitamin D Status of HIV-Infected Women and Its Association with HIV Disease Progression, Anemia, and Mortality. *Public Library of Science ONE, 5*, e8770. doi:10.1371/journal.pone.0008770

Merlino, M. A., Curtis, J., Mikuls, T. R., Cerhan, J. R., Criswell, L. A., & Saag, K. G. (2004). Vitamin D intake is inversely associated with rheumatoid arthritis: Results from the Iowa Women's Health Study. *Arthritis Rheumatism, 50*(1), 72-7.

Mithal, A., Wahl, D. A., Bonjour, J. P., Burckhardt, P., Dawson-Hughes, B., Eisman, J. A., . . . Morales-Torres, J. (2009). Global vitamin D status and determinants of hypovitaminosis D. *Osteoporosis International, 20,* 1807-20. doi: 10.1007/s00198-009-0954-6.

Mowry, E. M., Krupp, L. B., Milazzo, M., Chabas, D., Strober, J. B., Belman, A. L., . . . Waubant, E. (2010). Vitamin D status is associated with relapse rate in pediatric-onset multiple sclerosis. *Annals of Neurology, 67*(5), 618-624. doi: 10.1002/ana.21972.

Munger, K. L., Levin, L. I., Hollis, B. W., Howard, N. S.,& Ascherio, A. (2006). Serum 25-hydroxyvitamin D levels and risk of multiple sclerosis., *The Journal of the American Medical Association,* 296(23), 2832-2838.

National Institute of Health. (2012). Osteoporosis: Peak bone mass in women. Osteoporosis and Related Bone Diseases National Resource Center. Retrieved from: http://www.niams.nih.gov/Health_Info/Bone/Osteoporosis/bone_mass.asp

Nilsson, M., Ohlsson, C., Odén, A., Mellström, D., & Lorentzon, M. (2012). Increased physical activity is associated with enhanced development of peak bone mass in men: A five year longitudinal study. *Journal of Bone Mineral Research*. Advanced Online Publication. doi: 10.1002/jbmr.1549.

Odegaard, J. I., & Chawla, A. (2012). Connecting type 1 and type 2 diabetes through innate immunity. *Cold Spring Harbor Perspectives in Medicine, 2*(3), a007724. doi: 10.1101/cshperspect.a007724

Osteoporosis Society of Canada (2012). Vitamin D: An important nutrient that protects

you against falls and fractures. Retrieved from:
http://www.osteoporosis.ca/osteoporosis-and-you/nutrition/vitamin-d/

Osteoporosis Society of Canada (2008). Breaking barriers, not bones: The 2008 national report card on osteoporosis care. Retrieved from: http://www.osteoporosis.ca/multimedia/images/english/home/ 2008NationalReportCard_Eng.pdf

Papaioannou, A., Morin, S., Cheung, A. M., Atkinson, S., Brown, J. P., Feldman, S., . . . Leslie, W. D. (2010). The 2010 clinical practice guidelines for the diagnosis and management of osteoporosis in Canada: Summary. *Canadian Medical Association Journal, 182*(17)*,* 1864-1873. doi: 10.1503/cmaj.100771.

Park, E. A. (1940). The therapy of rickets. *Journal of American Medical Association, 115*(5)*,* 370–379. doi:10.1001/jama.1940.72810310011009a

Pittas, A. G., Dawson-Hughes, B., Li, T., Van Dam, R. M., Willett, W. C., Manson, J. E., & Hu, FB. (2006). Vitamin D and calcium intake in relation to type 2 diabetes in women. *Diabetes Care, 29*(3), 650-656.

Racette, S. B., Deusinger, S. S., Strube, M. J., Highstein, G. R., & Deusinger, R. H. (2005). Weight changes, exercise, and dietary patterns during freshman and sophomore years of college. *Journal of American College of Health, 53*(6), 245-251.

Ramagopalan, S. V., Maugeri, N. J., Handunnetthi, L., Lincoln, M. R., Orton, S. M., Dyment, D. A., . . . Knight, J. C. (2009). Expression of the multiple sclerosis-associated MHC class II Allele HLA-DRB1*1501 is regulated by vitamin D. *Public Library of Science Genetics, 5*(2), doi:10.1371/journal.pgen.1000369

Reginster, J-Y. (2005). The high prevalence of inadequate serum vitamin D levels and implications for bone health. *Current Medical Research and Opinion, 21*(4), 579- 585.

Rizzoli, R., Boonen, S., Brandi, M. L., Burlet, N., Delmas, P., & Register, J. Y. (2008). The role of calcium and vitamin D in the management of osteoporosis. *Bone, 42(2),* 246-249.

Rokeach, M. (1973). *The Nature of Human Values*. New York, NY: Free Press.

Rosenstock. I. M., (1966). Why people use health services. *Milbank Memorial Fund Quarterly, 44*, 94ff.

Ross, A. C., Manson, J. E., Abrams, S. A., Aloia, J. F., Brannon, P. M., Clinton, S. K, . . Shapses, S. A. (2011). The 2011 report on dietary reference intakes for calcium and vitamin D: What clinicians need to know. *Journal of Clinical Endocrinology and Metabolism, 96*(1), 53–58. doi: 10.1210/jc.2010-2704

Roth, D. E., Prosser, C., Martz, P., Prosser, C., Bell, M., & Jones, A. B. (2005). Are national guidelines sufficient to maintain adequate blood levels in children? *Canadian Journal of Public Health, 96*(6), 443-449.

Roux, C., Bischoff-Ferrari, H. A., Papapoulos, S. E., de Papp, A. E., West, J. A., & Bouillon, R. (2008). New insights into the role of vitamin D and calcium in osteoporosis management: an expert roundtable discussion. *Current Medical Research and Opinion, 24*(5), 1363-1370. doi: 10.1185/030079908X301857

Rucker, D., Allan, J. A., Fick, G. H., & Hanley, D. A. (2002). Vitamin D insufficiency in a population of healthy western Canadians. *Canadian Medical Association Journal, 166*(12), 1517-1524.

Schwalfenberg, G. (2007). Not enough vitamin D: Health consequences for Canadians.

Canadian Family Physician, 53(5), 841-54.

Schwalfenberg, G. K., Genuis, S. J., & Hiltz, M. N. (2010). Addressing vitamin D deficiency in Canada: A public health innovation whose time has come. *Public Health, 124*(6), 350-359. doi: 10.1016/j.puhe.2010.03.003

Simpson, M., Brady, H., Yin, X., Seifert, J., Barriga, K., Hoffman, M., . . . Norris, J. M. (2011). No association of vitamin D intake or 25-hydroxyvitamin D levels in childhood with risk of islet autoimmunity and type 1 diabetes: The diabetes autoimmunity study in young (DAISY). *Diabetologia, 54*(11), 2779-2788. doi: 10.1007/s00125-011-2278-2

Simpson, S. Jr., Taylor, B., Blizzard, L., Ponsonby, A. L., Pittas, F., Tremlett H., . . . van der Mei, I. (2010). Higher 25-hydroxyvitamin D is associated with lower relapse risk in multiple sclerosis. *Annals of Neurology, 68*(2), 193-203. doi: 10.1002/ana.22043.

Smolders, J., Menheere, P., Kessels, A., Damoiseaux, J., & Hupperts, R. (2008). Association of vitamin D metabolite levels with relapse rate and disability in multiple sclerosis. *Multiple Sclerosis, 14*(9), 1220-1224. doi: 10.1177/1352458508094399

Statistics Canada. (2008). *2006 Census of Canada: Ethnocultural Portrait of Canada Highlight Tables.* (Cat. No. 97562XWE2006002) [Tables]. Available from http://www12.statcan.ca/census-recensement/2006/rt-td/eth-eng.cfm

Statistics Canada. (2010). Postsecondary Student Information System. Age Distribution of University Students, 1992 and 2007 (chart) (Cat. No. 81-004-X). Available from: http://www.statcan.gc.ca/pub/81-004-x/2010005/chrt-graph/desc/desc-1b-eng.htm

Stewart-Brown, S., Evans, J., Patterson, J., Petersen, S., Doll, H., Balding, J., & Regis,

D. (2000). The health of students in higher education: An important and neglected public health problem. *Journal of Public Health and Medicine, 22*(4), 492-499.

Survey Monkey. (2011). How worried should Canadians be about the U.S. Patriot Act? Retrieved from: https://blog.surveymonkey.com/blog/2011/05/10/patriot-act/

Toubi, E., & Shoenfeld, Y. (2010). The role of vitamin D in regulating immune responses. *Israel Medical Association Journal, 12*(3)*,*174 -175.

Tucker, P., & Irwin, J. D. (2011). University students' satisfaction with, interest in improving, and receptivity to attending programs aimed at health and well-being. *Health Promotion Practice, 12*(3)*,* 388-395. doi: 10.1177/1524839908330814

Western University. (2012). Common university Data Ontario – 2012. Table A6 - Total enrollment by program. Retrieved from: http://www.ipb.uwo.ca/documents/cudo2012.pdf

van Etten, E. & Mathieu, C. (2005). Immunoregulation by 1,25-dihydroxyvitamin D3: Basic concepts. *Journal of Steroid Biochemistry & Molecular Biology, 97*(1-2)*,* 93-101.

Vatanparast, H., Calvo, M. S., Green, T. J., & Whiting, S. J.(2010). Despite mandatory fortification of staple foods, vitamin D intakes of Canadian children and adults are inadequate. *Journal of Steroid Biochemistry and Molecular Biology, 121*(1-2)*,* 301–303. doi: 10.1016/j.jsbmb.2010.03.079

Vieth, R. (1999). Vitamin D supplementation, 25-hydroxyvitamin D concentrations, and safety. *The American Journal of Clinical Nutrition, 69*(5)*,* 842-856.

Vieth, R. (2004). Why the optimal requirement for vitamin D3 is probably much higher than what is officially recommended for adults. *Journal of Steroid Biochemistry &*

Molecular Biology, 89-909(1-5), 75-579.

Vieth, R. (2007). Vitamin D toxicity, Policy, and Science. *Journal of Bone and Mineral Research, 22*, V64-V68. doi: 10.1359/JBMR.07S221

Vieth, R. (2012).Implications for 25-hydroxyvitamin D testing of public health policies about the benefits and risks of vitamin D fortification and supplementation, *Scandinavian journal of clinical & laboratory investigation. Supplement [0085-591X], 243,* 144-153. doi: 10.3109/00365513.2012.682893.

Vieth, R. (2011). Why the minimum desirable serum 25-hydroxyvitmin D level should be 75 nmol/L (30ng/ml), *Best practices & Research Clinical Endocrinology & Metabolism, 25*(4)*,* 681-691. doi: 10.1016/j.beem.2011.06.009

Vieth, R., Bischoff-Ferrari, H., Boucher, B. J., Dawson-Hughes, B., Garland, C.F., Heaney, R.P., . . . Zittermann, A. (2007). The urgent need to recommend an intake of vitamin D that is effective. *American Journal of Clinical Nutrition*, *85*(3), 649-50.

Vieth, R., Kimball, S., Hu, A., & Walfish, P. G. (2004). Randomized comparison of the vitamin D3 adequate intake versus 100 mcg (4000 IU) per day: Biochemical responses and effects on wellbeing of patients. *Nutrition Journal, 3,* 8. doi: 10.1186/1475-2891-3-8

Vieth, R., Ladak, Y., & Walfish, P. G. (2003) Age-Related Changes in the 25-Hydroxyvitamin D Versus Parathyroid Hormone Relationship Suggest a Different Reason Why Older Adults Require More Vitamin D*. Journal of Clinical Endocrinology& Metabolisim, 88*(1)*,* 185-191.

Von Ah, D., Ebert, S., Ngamvitroj, A., Park, N., & Kang, D. H. (2005). Predictors of health behaviours in college students. *Journal of Advanced Nursing, 48*, 463-474.

doi: 10.1111/j.1365-2648.2004.03229.x

von Bothmer, M. I. K., & Fridlund, B. (2005). Gender differences in health habits and in motivation for a healthy lifestyle among Swedish university students. *Nursing & Health Sciences, 7*(2), 107-118.

Vu, L. H., van der Pols, J. C., Whiteman, D. C., Kimlin, M. G., & Neale, R.E. (2010). Knowledge and attitudes about vitamin D and impact on sun protection practices among urban office workers in Brisbane, Australia. *Cancer Epidemiology, Biomarkers & Prevention, 19*(7) 1784-1789. doi: 10.1158/1055-9965.EPI-10-0127

Wagner, C. L., & Greer, F. R. (2008) Prevention of rickets and vitamin D deficiency in Infants, children, and adolescents. *Pediatrics, 122*(5), 1142-1152. doi: 10.1542/peds.2008-1862.

Ward, L. M., Gaboury, I., Ladhani, M., & Zlotkin, S. (2007). Vitamin D-deficiency rickets among children in Canada. *Canadian Medical Association Journal,177,* 161-166.

Wdowik, M. J., Kendall, P. A., Harris, M. A. & Auld, G. (2001). Expanded Health Belief Model Predicts Diabetes self-management in college students. *Journal of Nutrition Education, 33*(1)*,* 17-23.

Webb, A. R., Kline, L., & Holick, M. F. (1988). Influence of season and latitude on the cutaneous synthesis of vitamin D3: Exposure to winter sunlight in Boston and Edmonton will not promote vitamin D3 synthesis in human skin. *Journal of Clinical Endocrine and Metabolism,* 67(2), 373-378.

Weiler, H. A., Leslie, W. D., Krahn, J., Steiman, P. W., & Metge, C. J. (2007). Canadian Aboriginal women have a higher rate of vitamin D deficiency than non-Aboriginal women status despite similar dietary vitamin D intakes. *Journal of Nutrition,* 137(2), 461-465.

White, J. H. (2008). Vitamin D signaling, infectious diseases, and regulation of innate immunity, *Infection and Immunity, 76*(9)*,* 3837-3843. doi: 10.1128/IAI.00353-08

Whiting,S. J., Langlois, K. A., Vatanparast, H., & Greene-Finestone, L. S. (2011). The vitamin D status of Canadians relative to the 2011 dietary reference intakes: An examination in children and adults with and without supplement use. *The American Journal of Clinical Nutrition, 94*(1)*,* 128-135. doi: 10.3945/ajcn.111.013268

Wilkins, C. H., Sheline, Y. I., Roe, C. M., Birge, S. J., & Morris, J. C. (2006). Vitamin D deficiency is associated with low mood and worse cognitive performance in older adults. *American Journal of Geriatric Psychiatry,14*(12), 1032-1340.

Yetley, E. A. (2008). Assessing the vitamin D status of the US population. *American Journal of Clinical Nutrition* , 88(2), 558S- 64S.

Yetley, E. A., Brule, D., Cheney, M. C., Davis, C. D., Esslinger, K. A., Fischer, P. W. F., . . . Trumbo, P.R. (2009). Dietary reference intakes for vitamin D: Justification for a review of the 1997 values. *American Journal of Clinical Nutrition, 89(3)*, 719–727. doi: 10.3945/ajcn.2008.26903

Zhao, G., Ford, E. S., Li, C., & Croft, J. B. (2012). Serum 25-hydroxyvitamin D levels and all-cause and cardiovascular disease mortality among US adults with hypertension: the NHANES linked mortality study. *Journal of Hypertension, 30*(2)*,* 284-289.

doi: 10.1097/HJH.0b013e32834e1f0a.

Zipitis, C.S., Elazabi, E., & Samanta, S. (2011). Vitamin D deficiency and guideline awareness. *Archives of Disease in Childhood. Fetal and Neonatal Edition, 96*(4), F310. doi:10.1136/adc.2010.207977

Zittermann A. (2006). Vitamin D and disease prevention with special reference to cardiovascular disease. *Progression in Biophysics and Molecular Biology, 92,* 39-48.

Appendix A

Western University Office of Research Ethics Approval Certificate

Western

Research Ethics

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Jennifer Irwin
File Number: 103085
Review Level: Delegated
Approved Local Adult Participants: 200
Approved Local Minor Participants: 0
Protocol Title: University Students' Vitamin D Knowledge and Values
Department & Institution: Health Sciences, Western University
Sponsor:
Ethics Approval Date: November 08, 2012 **Expiry Date:** April 30, 2013
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Advertisement	Reminder Email Script for Recruitment	
Other	Vitamin D Knowledge Survey (VD-KS)	
Other	The Vitamin D Values Survey	
Revised Western University Protocol		
Advertisement		

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the University of Western Ontario Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Signature

Ethics Officer to Contact for Further Information

Janice Sutherland	✓ Grace Kelly	Shantel Walcott

This is an official document. Please retain the original in your files.

Western University, Support Services Bldg Rm. 5150 London, ON, Canada N6A 3K7
t. 519.661.3036 f. 519.850.2466 www.uwo.ca/research/ethics

Appendix B

Email Script for Recruitment

Subject Line: Invitation to participate in research

You are being invited to participate in a study conducted by Shaunessey Boland (student researcher). Briefly, the study involves completing two short anonymous on-line surveys that will take less than 10 minutes of your time. In two weeks, a reminder email will be sent to invite those who have not completed the survey to participate.

If you would like to participate in this study please click on the link below to access the letter of information and survey link.

https://www.surveymonkey.com/s/H7M9V2W

Thank you,

Shaunessey Boland (MSc Candidate)
Western University

Jennifer D Irwin, PhD

Appendix C

Letter of Information

Western

Project Title: University Students Vitamin D Knowledge and Values

Principal Investigator:

Jennifer D. Irwin, Ph.D, School of Health Studies, Western University

Letter of Information

You are being invited to participate in this research study, investigating students' vitamin D knowledge and values, because students are in need of health promotion programming and are therefore the focus of the study.

The purpose of this letter is to provide you with information required for you to make an informed decision regarding participation in this research.

The purpose of this study is to understand what students know about vitamin D and what they value about it and its' health effects.

All undergraduate students registered at Western University are eligible to participate in this study.

If you agree to participate, you will be asked to complete two short surveys about vitamin D. It is anticipated that the entire task will take less than 10 minutes to complete. The surveys will be conducted online through a survey link.

There are no known or anticipated risks or discomforts associated with participating in this study.

The possible benefits of participating are that those who participate in the study may feel inclined to learn more about vitamin D as a result of their participation. The future benefits of participating in this study are that the results can be used to create effective programs designed to decrease vitamin D insufficiency in student populations and increase the knowledge and health of students. It is likely that the students that participate in this study may be the target of future programming aimed at promoting their own health and wellbeing through vitamin D adequacy

You will not be compensated for your participation in this research.

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your future academic status.

All data collected will remain anonymous. The research records will be stored in the following manner: locked in a cabinet in a secure office; and they will be destroyed after 2 years.

If you require any further information regarding this research project or your participation in the study you may contact Jennifer D. Irwin, or Shaunessey Boland.

If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Research Ethics.

If the results of the study are published, your name will not be used. If you would like to receive a copy of any potential study results, please contact Jennifer D. Irwin, or Shaunessey Boland.

Completion of the survey is indication of your consent to participate.

This letter is yours to keep for future reference.

Appendix D

Vitamin D Knowledge Survey

Vitamin D Knowledge Survey

1. Have you heard of vitamin D?
   - Yes
   - No

- If you have NOT heard of vitamin D, please skip to the values survey by clicking the link below or copying it to your browser:

  https://www.surveymonkey.com/s/CCRHKSB

2. Where did you hear about vitamin D?
   - Physician/ Nurse
   - Other Health Professional
   - School
   - Newspaper
   - Family
   - Friend
   - Television
   - Radio
   - Poster/ Billboard
   - Magazine
   - Book
   - I don't know
   - Other________

3. Where do you think vitamin D comes from? (check all that are correct)
   - I don't know
   - Fruits
   - Water
   - Vegetables
   - Fatty fish*
   - Vitamin D supplements*
   - Sun*
   - Air
   - Select cereals*
   - Milk/ Dairy*
   - Nuts
   - Cod liver oil*
   - Chicken
   - Eggs*
   - Mushrooms*

4. Vitamin D helps with which of the following health effects (check all that apply):
   - I don't know
   - Bone health*
   - Immune health*
   - Prevention of Rickets*
   - Vision Health
   - Pregnancy/ Breastfeeding *
   - Hair Growth
   - Prevention of diabetes*
   - Cardio-vascular health*
   - Cognitive health*
   - Cancer prevention*

- Osteoporosis prevention*
- Disease prevention*
- Skin softness
- Calcium absorption*
- None of the above
- Other_______

5. What is the daily amount of vitamin D currently recommended for adults (under 70 years) by Health Canada?
   - I don't know
   - 200 International Units
   - 400 International Units
   - 600 International Units*
   - 800 International Units
   - 1000 International Units
   - 1500 International Units
   - 2000 International Units

6. How much time would the average fair-skinned person need to spend in the sun to get enough vitamin D, if their bare legs and arms were exposed?
   - I don't know
   - Less than 10 minutes per week
   - 1-2 hours per week
   - More than 2 hours a week
   - 10-60 minutes per week*

7. How much time would the average non-fair-skinned (i.e., non-Caucasian) person need to spend in the sun to get enough vitamin D, if their bare legs and arms were exposed?
   - I don't know
   - Less than 10 minutes per week
   - About 1-6 hours per week*
   - 10-20 minutes a week
   - More than 6 hours per week

8. Factors that can decrease the amount of vitamin D a person can get are (check all that apply):
   - Skin pigment*
   - Shade/ clouds*
   - Time of day*
   - Latitude*
   - Season*
   - Age*
   - Pregnancy/ lactation*
   - Fatty diets
   - Sunscreen use*
   - Vegan diet*
   - Vegetarian diets*
   - Lactose intolerance*
   - Dairy allergy*
   - Pollution*
   - Wind
   - Smoking
   - Body Mass Index*
   - Other

9. What percentage of the Canadian population is estimated to be vitamin D insufficient (i.e., getting less than what is recommended by Health Canada)?
   - o 5%
   - o 0.5%
   - o 10%
   - o 0%
   - o 25%*

<u>Additional Question</u>

10. How much vitamin D do you take daily?
    - o I don't take a vitamin D supplement
    - o I take vitamin D supplements but I don't know how much I take
    - o I only take a multivitamin
    - o I take _______ vitamin D

<u>Demographic Questions</u>

1. What is your age?
   - o _______

2. What is your gender?
   - o Male
   - o Female

3. What ethnicity best describes you?
   - o Latino
   - o Native
   - o Black
   - o Caucasian (White)
   - o Asian
   - o Middle eastern
   - o Other _____

4. What academic program are you in?

School: ______________ Faculty:______________ Program: ______________

*If you would like to learn more about the results of this study, please contact:

Shaunessey Boland

Note. Correct responses are denoted with an astrix (*)

Appendix E

Curriculum Vitae

Name:	Shaunessey Boland
Post-secondary Education and Degrees:	University of Western Ontario London, Ontario, Canada 2004-2008 Honours Specialization B.A. The University of Western Ontario London, Ontario, Canada 2010-2013 M.Sc.
Honours and Awards:	Dean's List (B.A) 2004-2008 Dean's List (M.Sc.) 2010-2011 Ontario Graduate Scholarship 2010-2011
Related Work Experience	Teaching Assistant, Indigenous Services 2010-2011: The University of Western Ontario ▪ Assist students with classes in health promotion, psychology, sociology, social work, research methods, statistics and math ▪ Facilitate seminars, group discussions and study sessions ▪ Tutor students and assist in preparation for exams and assignments Research Assistant, Health Literacy Project 2010-2011: The University of Western Ontario ▪ Investigated health literacy of incarcerated females ▪ Assisted in research planning as part of a multidisciplinary team Research Assistant, Health Psychology Lab 2006: The University of Western Ontario

- Investigated effects of the Patient - Health Care Provider relationship on aspects of chronic pain
- Collected data by assisting in survey completion

Publications:

Boland, S. (2008). False memories, dissociation and need for cognition in the DRM paradigm. Honours Theses for psychology 491, Vol 1, King's University College at The University of Western Ontario: London, ON.