The Glycemic Index Concept Uptake and Dietary Assessment in Type 2 Diabetes

by

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Abstract

Effective dietary self-management is essential for metabolic control and prevention of complications for improved health outcomes and quality of life among individuals with diabetes. This body of research examined dietary self-management practices and effectiveness of a web-based lifestyle modification intervention designed to enhance uptake of guideline recommendations of Diabetes Canada (formerly Canadian Diabetes Association) regarding the glycemic index (GI) concept for improving carbohydrate and overall diet quality.

The intervention, guided by the Social Cognitive Theory principles of self-efficacy and social support, was based on current Diabetes Canada recommendations and tailored to deliver simple, actionable messages around the GI concept, which is often regarded as a difficult topic to teach. Findings from this research have shown that using a bundle of patient preferred modes of delivering GI-targeted nutrition information has great potential for changing dietary habits. Specifically, it was shown that adults with type 2 diabetes (T2D) who were randomized to a 12-week web-based intervention increased GI knowledge and self-efficacy with a significant reduction in mean daily GI intakes. Furthermore, this research has increased our understanding of the readiness of the older adult population for web-based lifestyle interventions. This is an important finding, which can inform future web-based interventions by researchers and healthcare specialists supporting people with T2D. Given these findings, future research involving larger, more diverse sample may be needed to expand on the feasibility and usefulness of this alternative approach for bridging GI knowledge translation gaps in other populations as well as integration within clinical care and self-management support for people with diabetes.

Preface

This thesis is a compilation of original work done by Hayford Mawuli Avedzi under the supervision of Prof. Jeffrey A. Johnson and co-supervisors Dr. Steven T. Johnson and Dr. Kate E. Storey. The University of Alberta Health Research Ethics Board granted research ethics approval for Healthy Eating and Active Living for Diabetes (HEALD), File No.: Pro00008427, led by Prof. Jeffrey A. Johnson, which provided data for Chapter 2 of this thesis. The Diet and Physical Activity in Adults with Type 2 Diabetes: A Sub-study of the ABCD Diabetes Complications Study, led by Prof. Jeffrey A. Johnson, which provided data for Chapter 3 of this thesis also received ethical approval (File No.: Pro00044665, January 31, 2014) from the University of Alberta Health Research Ethics Board. Finally, the Health Research Ethics Boards at Athabasca University (File No.: 22355, October 20, 2016) and University of Alberta (File No.: Pro00068291, November 17, 2016) provided research ethics approvals for the Healthy Eating and Active Living for Diabetes - Glycemic Index (HEALD-GI) Trial, led by Dr. Steve T. Johnson. The research protocol for the HEALD-GI Trial (Appendix) was developed by Hayford Mawuli Avedzi under the supervision of Prof. Jeffrey A. Johnson (School of Public Health, University of Alberta), Dr. Steve T. Johnson (Athabasca University), and Dr. Kate E. Storey (School of Public Health, University of Alberta) and provides data for Chapter 4 and 5 of this thesis. All data were collected from the population of people with diabetes in Alberta. Allison Soprovich, RN, MPH assisted me with the HEALD-GI data collection and Donna Pressick provided administrative assistance in setting up data collection appointments with study participants.

Chapter 2 of this thesis has been published as: Avedzi H, Mathe N, Bearman S, Storey K, Johnson JA, Johnson ST. Examining dietary practices among adults with type-2 diabetes: a focus on low glycemic index choices. Canadian Journal of Dietetic Practice and Research 2017;78(1):26-31; PMID: 27779892. I was responsible for data analysis and manuscript composition while Johnson ST, the supervisory author, Mathe N, Storey K, and Johnson JA contributed to concept formation and content reviews. Bearman S reviewed contents.

A version of Chapter 3 has been published as: Avedzi H, Mathe N, Storey K, Johnson JA, Johnson ST. Examining Sex Differences in Glycemic Index Knowledge and Intake Among Individuals with Type 2 Diabetes. Primary Care Diabetes 2018;12(1):71-79. PMID: 28823516. I analyzed data and drafted the manuscript while Johnson ST, the supervisory author, Mathe N, Storey K, and Johnson JA contributed to concept formation and content reviews.

The HEALD-GI Trial protocol (Appendix) has been published as Avedzi HM, Storey K, Johnson JA, Johnson ST. Healthy Eating and Active Living for Diabetes- Glycemic Index (HEALD-GI): Protocol for a Pragmatic Randomized Controlled Trial. JMIR Research Protocols 2019;8(3):e11707. PMID: 30839283. I developed the concept, analyzed data, and drafted the manuscript while Johnson ST, the supervisory author, Storey K, and Johnson JA contributed to concept formation and content reviews.

All data analyses, interpretations, manuscript compositions, and literature reviews are my original work with guidance from my supervisory committee. As the author, I take full responsibility for any error or misrepresentation in this thesis.

Dedications

To Jehovah God Almighty for the gift of life and every blessing I receive.

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Glossary of Terms

24-HDR	24-hour dietary recall
2hPG	2-Hour Plasma Glucose
3-DFR	3-day food records
ABCD	Alberta's Caring for Diabetes
AHEAD	Action for Health in Diabetes (Look AHEAD)
AMDR	Acceptable Macronutrient Distribution Range
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
BMI	Body Mass Index
CCD	The Canadian Trial of Carbohydrates in Diabetes
CFG	Canada's Food Guide
CHO	Carbohydrate
CRP	C-reactive protein
CVD	Cardiovascular Disease
DASH	Dietary Approaches to Stop Hypertension
DC	Diabetes Canada
DoC	Dietitians of Canada
DPP	Diabetes Prevention Program
DPPOS	Diabetes Prevention Program Outcomes Study
DPS	Diabetes Prevention Study
DSE	Diabetes Support and Education
FFQ	Food Frequency Questionnaires

FPG	Fasting Plasma Glucose
GI	Glycemic Index
GL	Glycemic Load
HbA1c	Glycated Hemoglobin A1c
HBM	Health Belief Model
HEALD-PCN	Healthy Eating and Active Living for Diabetes in Primary Care Networks
IGT	Impaired Glucose Tolerance
ICQC	International Carbohydrate Quality Consortium
MMS	Multimedia Message Service
MNT	Medical Nutrition Therapy and Type
NLI	Intensive lifestyle intervention
OGTT	Oral Glucose Tolerance Test
RD	Registered Dietitian
RPG	Random Plasma Glucose
SCT	Social Cognitive Theory
SDSCA	Summary of Diabetes Self-Care Activities
SEM	Social Ecological Model
SMS	Short Message Service
SSB	Sugar-Sweetened Beverage
T2D	Type 2 Diabetes
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
TTM	Transtheoretical Model

CHAPTER 1

General Introduction

1.1.0 Overview

Living with diabetes, a chronic progressive disease, increases risk for multiple acute and long-term complications and disability, which affect quality of life, increase risk for early death and higher national healthcare costs [1, 2]. Health outcomes for individuals with diabetes depend largely on their ability to effectively carry out a range of daily self-management activities including healthy eating, physical activity, medication, blood glucose monitoring, and foot care. Lifestyle modification, including healthy eating and physical activity, has been advocated as the foundation for effective diabetes self-management by major diabetes organizations, including Diabetes Canada (DC) and the American Diabetes Association [3, 4]. Given that diabetes amplifies the need to maintain healthy dietary practices, Diabetes Canada Clinical Practice Guidelines recommend nutrition therapy from a Registered Dietitian (RD) for people with diabetes that emphasizes lifestyle and ethno-culturally sensitive healthy eating dietary patterns that promote adherence to consumption of a variety of healthy foods. Included in the Clinical Practice Guidelines is the recommendation to replace high glycemic index (GI) with low-GI carbohydrates [2]. This recommendation is based on different grades and levels of evidence from meta-analytic data, randomized controlled feeding and pragmatic trials, and observational studies aimed at lifestyle modification [2, 5]. Given that healthcare providers and researchers supporting diabetes patients and policy makers need reliable evidence regarding self-management activities to identify aspects of self-care behaviours that need to be altered for improved health outcomes, further research evaluating uptake of current recommendations are needed to direct future guidelines and practice.

Attaining and maintaining optimal nutrition is associated with clinically significant improvements in metabolic and clinical outcomes such as glycemic control (i.e. decreased glycated hemoglobin A1c), cardiovascular risk factors including dyslipidemia, body weight, diabetes complications and hospitalization rates [6-9]. Similarly, replacing high-GI carbohydrates with healthy low-GI options, which elicit lower glycemic response, within the same food group has been shown to have additional benefits for short-term metabolic control and long-term optimal health outcomes [2, 10, 11]. Achieving these outcomes requires providing practical tools and support for individuals with diabetes to enhance day-to-day meal planning that includes low-GI foods. However, clinical usefulness of the GI-concept has been fiercely debated and hence its translation to people with diabetes has been hindered [12, 13]. For example, people with diabetes have expressed GI educational needs [14], inadequate nutrition care [15] and reported insufficient GI knowledge [16, 17]. Furthermore, lack of GI teaching tools and GI concept complexity reported among Registered Dietitians in Canada have resulted in inefficient translation of the GI concept for uptake among people with diabetes [18, 19].

This program of research was therefore set up to understand GI concept-related dietary practices and factors influencing uptake of the GI concept as part of healthy eating behaviour among people living with T2D. In addition, this research aims to evaluate the effectiveness of a dietary lifestyle modification intervention based on low-GI guideline recommendations [2] using web-based information technologies for engaging, educating, and empowering individuals with chronic diseases such as diabetes [20, 21]. Guided by the principles of self-efficacy and social support as captured by Social Cognitive Theory [22], this research aims to contribute reliable and applicable evidence around the GI concept utility and translation for enhancing lifestyle modification and informing clinical practice and future research.

1.2.0 Type 2 Diabetes Definition and Diagnosis

Diabetes mellitus is a metabolic disorder characterized by chronic elevated blood glucose due to the body's inability to produce enough insulin and/or utilize insulin effectively. Insulin is needed to transport glucose into cells for use by body tissues and organs. Type-1 diabetes, type-2 diabetes (T2D) and gestational diabetes constitute the three main types of diabetes. Besides these types of diabetes, prediabetes, characterized by higher than normal blood glucose levels but not yet high enough to be diagnosed as diabetes, affects many individuals thereby increasing their risk for diabetes [1, 3, 23].

Also known as adult onset diabetes or non-insulin dependent diabetes, T2D constitutes about 95% of all diabetes cases and has been linked to various risk factors. Sex (male or female), having a family history of diabetes, gestational diabetes, low socio-economic status, belonging to a high-risk ethno-cultural population (such as First Nation peoples), ageing population, and lifestyles characterized by over nutrition and physical inactivity together give rise to obesity, a risk factor for T2D [1, 3, 23]. T2D results in elevated blood glucose known as hyperglycemia, which is mediated by impaired insulin secretion and action.

Currently, in Canada, T2D is diagnosed by the following methods: fasting plasma glucose (FPG) $\geq$7.0 mmol/L, where fasting refers to no caloric intake for at least 8 hours; or glycated hemoglobin A1C $\geq$6.5%; 2-hour plasma glucose (2hPG) in a 75 g oral glucose tolerance test (OGTT) $\geq$11.1 mmol/L; or random plasma glucose (RPG) $\geq$11.1 mmol/L. A1c and RPG can be carried out at anytime of the day without regard to the interval since the last meal. It is recommended that a repeat confirmatory laboratory test (FPG, A1C, 2hPG in a 75 g OGTT) must be completed on another day, preferably using the same test [3]. Similar diagnostic criteria are employed by the American Diabetes Association [4].

1.2.1 Pathophysiology

In most people with T2D, a collection of risk factors including abdominal obesity, hypertension, dyslipidemia and insulin resistance are often present. These metabolic disorders constitute what has been referred to as Metabolic Syndrome and increase the risk for cardiovascular disease (CVD) and mortality [3, 4]. Whether due to the body's inability to produce enough insulin and/or utilize insulin effectively, lifestyle or pharmacologic interventions are needed to improve health outcomes. When left unattended over time, chronic uncontrolled elevated blood glucose can result in costly acute and long-term complications [3, 4]. Individuals with T2D are 3, 12, and 20 times more likely to be hospitalized with cardiovascular disease, end-stage kidney disease, and limb amputations respectively compared with people without diabetes [1].

1.2.2 Epidemiology

As at 2017, an estimated 451 million people aged 18 to 99 years live with diabetes globally. While this number is expected to increase to 693 million by 2045, almost half (49.7%) of all people living with diabetes are undiagnosed [24]. In 2010, approximately 7.3% of the Canadian population lived with diabetes and the prevalence has been projected to rise to about 10% by 2020 [25]. The increasing prevalence of T2D presents a major public health challenge, which affects quality of life, increases risk for early death and higher costs and strains on healthcare systems [1]. Novel, effective strategies are thus needed to augment and possibly challenge current approaches for prevention and management of the growing diabetes epidemic.

1.3.0 Lifestyle and Type 2 Diabetes

1.3.1 Diet and Etiology

Canada's growing prevalence of T2D is linked to obesity and unhealthy lifestyles. It has been estimated that over 60% of Canadians are overweight or obese [1] and an estimated 80-90% of people with T2D are overweight or obese [23, 26-29]. Excessive weight gain and obesity remain the fundamental link between diet and T2D. Obesity, particularly abdominal obesity, caused primarily by consumption of excess dietary energy (mostly from fats and carbohydrates) act through a complex physiological mechanism to increase an individual's risk for developing insulin resistance and diabetes [30, 31]. Findings from the Nurses Health Study in the US show that the risk of developing diabetes increases dramatically with increasing body mass index (BMI) [32]. Even after controlling for the effect of body weight, consumption of sugar-sweetened beverages (SSBs) in large quantities increased individuals' risk for T2D with most frequent consumption, (i.e. 1–2 servings/day) associated with a 26% T2D greater risk of T2D [33, 34]. Also, surges in blood glucose and insulin levels from consumption of large quantities of rapidly absorbable carbohydrates like sucrose found in SSBs can lead to an elevated dietary glycemic load with a net increase in insulin demand resulting in the proposed exhaustion of pancreatic beta-cells, which increases T2D and CVD risks over time [35]. Fructose from high fructose corn syrup has also been linked to increased production of fats in the liver, resulting in visceral adiposity, dyslipidemia, and insulin resistance [33, 36, 37].

Poor overall diet quality has also been shown to have independent effects on the development of diabetes besides the high calorie diet-obesity-T2D mechanism [38]. Fats and carbohydrates, specifically higher glycemic load carbohydrates and trans fat, were associated with increased diabetes risk while increased cereal fiber intake and polyunsaturated fat were associated with decreased diabetes risk [31, 33].

1.3.2 Lifestyle Modification and Diabetes Prevention

Lifestyle factors such as diet and physical activity are amenable to health promoting interventions for prevention of T2D. Research evidence and Clinical Practice Guidelines recommend lifestyle factors such as healthy diet and physical activity, maintenance of an ideal body weight and/or weight loss in overweight and obese individuals as essential lifestyle factors for diabetes prevention or management [33, 39, 40]. Evidence supporting these recommendations is summarized as follows.

The Da Qing impaired glucose tolerance (IGT) and Diabetes Study examined the effect of diet and exercise in preventing T2D in people with impaired glucose tolerance [41]. A total of 577 participants were randomized to one of 4 groups: diet, exercise, diet plus exercise, and a control group. The dietary goal was to allow 25-30% total energy from fat and to increase physical activity (i.e., walking) by 30 minutes per day. Lifestyle counseling was provided through individual and group counseling to participants. After a mean follow up period of 6 years, the risk reduction were: 31% (diet), 46% (exercise), and 42% (diet and exercise) [41].

The Finnish Diabetes Prevention Study (DPS) was one of the first randomized controlled studies to show that T2D could be prevented with lifestyle intervention [42]. In this study, 522 middle-aged overweight individuals (172 men and 350 women; mean age, 55 years) with impaired glucose tolerance were randomized to either a usual care control group or an intensive lifestyle intervention group. Participants in the control group received general dietary and exercise advice at baseline followed by an annual physician's examination. Those in the intervention group received additional intensive lifestyle intervention made up of individualized dietary counseling from a nutritionist, resistance training sessions and advise to increase overall physical activity. The intervention goals were to reduce body weight, reduce dietary and saturated fat, and increase physical activity and dietary fiber. The intervention was the most intensive during the first year, followed by a maintenance period. An oral glucose-tolerance test was performed annually and diagnosis of diabetes was confirmed by a second test. The mean duration of follow-up was 3.2 years. Results show that, between baseline and the end of the first year, a mean (SD) 4.2 (5.1) kg weight loss was achieved in the intervention compared with 0.8 (3.7) kg in the control group. By the end of year 2, a net weight loss of 3.5 (5.5) kg in the intervention versus 0.8 (4.4) kg in the control group ($P<0.001$) was observed. The risk of T2D was reduced by 58% ($P<0.001$) in the intervention group during the trial and was directly associated with changes in lifestyle [42, 43].

The Diabetes Prevention Program (DPP) reported in 2002 [44] is another piece of robust evidence linking obesity and diabetes. In this randomized controlled trial of 1,079 participants aged 25–84 years, a 58% reduction in T2D incidence over 3 years was reported in subjects treated with an intensive lifestyle intervention that included medical nutrition therapy increased physical activity, and weight loss (5-10% from baseline). The study also found that taking metformin, a safe and effective generic medicine to treat diabetes, prevented the disease, though to a lesser degree [44]. An ongoing DPP Outcomes Study (DPPOS) has continued to follow most DPP participants since 2002 has shown that participants who took part in the DPP or are taking metformin continue to prevent or delay type 2 diabetes for at least 10 years [45]. Also, based on the ongoing DPPOS, the DPP has been shown to be cost effective, that is, costs are justified by the benefits of diabetes prevention, improved health, and fewer health care costs while metformin is cost-saving, leading to a small savings in health care costs after 10-years [46].

More recently, the Look AHEAD (Action for Health in Diabetes) multicenter, randomized controlled trial was designed to determine whether intentional weight loss reduces cardiovascular morbidity and mortality in overweight individuals with T2D [47]. The study compared an Intensive Lifestyle Intervention (ILI) to a Diabetes Support and Education (DSE) among 5145 persons in 16 centers in the United States of America. The two main goals of the study were to induce a mean loss ≥ 7% of initial weight and to increase participants' moderately intense physical activity to ≥175 minutes per week. Throughout the 9.6 years of follow up, patients in the intensive therapy group lost more weight, exercised more, reached lower hemoglobin A1c levels, and required fewer medications (antihypertensives, statins, and insulin) despite not demonstrating any reduction in the composite primary endpoint of CV mortality, non-fatal MI, non-fatal stroke, or angina hospitalization. Other health benefits included less sleep apnea, lower liver fat, less depression, improved insulin sensitivity, less urinary incontinence, less kidney disease, maintenance of physical mobility and overall improved quality of life [47, 48]. These and other similar lifestyle interventions [49], underscore the benefits and importance of intensive health behaviour modification, specifically diet and physical activity, for diabetes prevention and management.

1.4.0 Theories of Behaviour Change

Behavioral and social factors, including tobacco use, poor diet, physical inactivity, alcohol and drug use, sexual behavior, and lack of access to medical care, are major contributors to morbidity and mortality [50]. Public health interventions, defined as programs and strategies intended to influence health and/or health-related behavior positively [51], are thus important for curbing, controlling or monitoring outcomes. However, it has been suggested that, to be effective, interventions developed to improve health behaviour and outcomes need explicit theoretical foundation(s) [51-53]. A theory presents a systematic way of understanding events, behaviours, and/or situations and is defined as a set of interrelated concepts, definitions, and propositions that explain or predict events or situations by specifying relations among variables [51, 54]. The importance of theories lies in their ability to help explain behaviour and suggest how best to develop effective ways to influence and change behaviour. Specifically, theories guide the quest to understand why people do or do not practice health-promoting behaviours, help identify the information needed for effective intervention strategies, and provide insight into how to design a program so that it is successful [51, 53, 54].

Five leading theories, which have extensive literature supporting their importance and utility, are discussed below, focusing on their psychosocial correlates relevant to health behaviour change among T2D patients. These theories include: the social cognitive theory, trans-theoretical model/stages of change, health belief model, theories of reasoned action and planned behaviour and social ecological model. They are either explanatory (e.g. health belief model), which offer explanatory interpretations for health behaviour, or change theory (e.g. stages of change/transtheoretical model), which helps to guide planned behaviour change efforts to improve health [51].

1.4.1. Social Cognitive (Learning) Theory

The social cognitive theory (SCT) is widely used in health promotion and addresses both the underlying determinants of health behaviour and methods of promoting change. Briefly, the SCT specifies a core set of constructs, the mechanism through which they work, and the optimal ways of translating this knowledge into effective health practices [55]. According to Bandura, the core constructs of SCT include knowledge of health risks and benefits of different health practices, perceived self-efficacy that one can exercise control over one's health habits, outcome expectations about the expected costs and benefits for different health habits, the health goals people set for themselves and the concrete plans and strategies for realizing them, and the perceived facilitators and social and structural impediments to the changes they seek [55, 56]. Bandura's work emphasizes the primacy of perceived self-efficacy, which is a person's confidence in his or her ability to take action and to persist in that action, as a key psychosocial construct for influencing health behaviour change efforts [56]. The structure, predictive power, and ease of operation of self-efficacy have been tested and proven across various domains including exercise participation in different settings [57]. Self-efficacy affects health behaviour directly and influences other determinants. Stronger perceived self-efficacy results in higher goals and firmer resolve to see them through. Besides, self-efficacy determines how obstacles and impediments are viewed as well as shapes outcome expectations such that individuals with higher perceived self-efficacy expect more favorable outcomes from their efforts [22, 55].

The SCT has been used in interventions to explain human behaviour in terms of a three-way, dynamic, reciprocal model in which personal factors, environmental influences, and behaviour continually interact [51]. Incorporating SCT for lifestyle interventions among people with T2D should target an increase in an individuals' self-efficacy for a particular behaviour by setting small, incremental and achievable goals. The increase in self-efficacy can be operationalized by using formalized behavioural contracting to establish goals and specify rewards; monitoring and reinforcement, including self-monitoring that involves keeping records of physical activity or dietary intakes using food records [51, 58]. The use of goal setting, family, and social support strategies of the SCT has been shown to be associated with greater fat reduction and higher fruit and vegetable intakes [59] and this could be adapted for individuals with T2D.

1.4.2 Transtheoretical Model/Stages of Change

The Transtheoretical Model (TTM), developed by Prochaska and DiClimente, describes and explains the different stages of change common to most behaviour change processes [58, 60]. The TTM views health behaviour adoption and maintenance as a cyclic process whereby individuals pass through a series of specific stages, characterized by a particular pattern of psychosocial and behavioral changes. Depending on an individual's readiness to change therefore, they are classified into one of five stages: pre-contemplation, contemplation, preparation, action, and maintenance, often referred to as "stages of change" [57, 60]. Typically, individuals in the 'Precontemplation' stage do not recognize the need for or interest in change (in the next six months) while those in the 'contemplation' stage are thinking about changing (in the next six months) and 'Preparation' stage involves planning for change (generally within the next month). Those in the 'Action' stage are often adopting new habits (for at least six months) while 'Maintenance' stage captures ongoing practice of new, healthier behaviour (over six months and chances to return to old behaviour are few) [51, 61]. Behaviour change researchers in their quest to overcome the limitations of the SCT model have used TTM extensively and it remains the most popular stage model in physical activity research. It has also been examined and found useful in explaining and predicting changes for a variety of behaviours including smoking, and eating habits in different settings [51, 57, 58, 62].

The TTM/stages of change model emphasizes the premise that behaviour change is a process, not an event, and that people are at different levels of readiness to adopt healthful habits. It can be used in diabetes interventions both to help understand why people at high-risk for diabetes might not be ready to attempt behavioural change, and to evaluate and improve the success of health counseling depending on the individual's stage of change. In a longitudinal test of the TTM's ability to predict physical activity stage transitions in a large sample of adults with type 1 and 2 diabetes, Plotnikoff et al [63] showed that self-efficacy, pros, and cognitive Processes of Change are key TTM constructs that predicted stage transition in the pre-action stages. They also showed that strategies that enhance the behavioral Processes of Change were more appropriate for the Action and Maintenance stages when promoting physical activity among adults with diabetes [63]. As such designing and implementing interventions, it is important to determine the needs of individuals' stages of change and target the appropriate construct(s) that best predicts transition for enhanced participation and retentions rates as well as reduce individuals' resistance to initiation of difficult behaviors [57, 62].

1.4.3 Health Belief Model

The health belief model (HBM) was one of the first and now most recognized health behaviour theories. It was originally used to explain participation in public health screening and immunization programs in the 1950's [64] but has evolved over the years for application to other types of health behaviour including sexual risk behaviours, injury prevention, mammography screening, and influenza vaccines [65]. Fundamental constructs of the Health Belief Model include: perceived susceptibility and perceived severity; perceived benefits and perceived barriers; cues to action and self-efficacy which was added more recently [51, 57, 58].

The HBM has found its application mostly in prevention-related interventions, where beliefs are as important or more important than overt symptoms such as hypertension and cancer screening. Since the HBM emphasizes beliefs of susceptibility and severity of a health problem, and perceived benefits and barriers of taking action, it is particularly relevant to interventions to reduce risk factors for cardiovascular disease complications among people with T2D because of their increased risk [51, 66].

1.4.4 Theories of Reasoned Action and Planned Behaviour

Developed by Ajzen and Fishbein, the theory of reasoned action (TRA) explains human behaviour under 'voluntary' control with the notion that individuals' likelihood of engaging in a particular health behaviour can be predicted by the strength of their intention to engage in that behaviour [58, 67-70]. Key constructs of the TRA are attitudes towards behaviour and subjective norms. While the TRA is said to be 'most useful for predicting behaviours under volitional or perceived control' [70], some behaviours are not entirely within an individual's control. To account for this limitation therefore, Ajzen proposed an extension of the TRA called the theory of planned behaviour (TPB), which incorporates TRA constructs in addition to perceived behavioural control. Perceived behavioural control, similar to self-efficacy, defines individuals' perceptions of their ability to perform a given behaviour [68, 70, 71].

The TRA/TPB highlights the need to understand the beliefs of the target group regarding the issue at hand, who they see as affecting these beliefs and their behaviour and what is perceived as barriers to taking actions that might promote health [58]. The TRA/TPB is well suited for measuring intention for healthy dietary practices and has been employed by Watanabe et al [68] in developing a valid tool for assessing TPB constructs that predict the intentions to eat a low-GI diet among people with diabetes. Findings from their study showed that three TPB constructs: instrumental attitude, subjective norms, and perceived behavioural control significantly predicted intentions to eat a low-GI diet among their study participants [68].

1.4.5 Social Ecological Model

The social ecological model (SEM) emphasizes multiple levels of influence including individual, interpersonal, organizational, community, and public policy with the idea that behaviors both shape and are shaped by the social environment [51, 72]. Similar to SCT, SEM suggests that creating an environment conducive to change is important to facilitate adoption of healthy behaviors [22, 51]. For example, an estimated 80-90% of people with T2D in Canada are overweight or obese [26]. As such, more attention could be focused on exploring and improving the health promoting features of communities and neighborhoods by reducing the ubiquity of high calorie, high-fat food choices [73].

Summary and conclusion: Together, healthy eating and active living can contribute significantly to the reduction of an estimated 50% of T2D [26, 74]. However, reducing these lifestyle-related health risks can be complicated and fail to yield the desired goals due to the complex web of personal, social, biological, and environmental factors that influences human behaviour. As such, lifestyle interventions that target behaviour change need to be underpinned by appropriate theories as interventions that are based on social and behavioral science theories are known more effective than those lacking a theoretical basis [51]. Therefore, in designing and evaluating effective lifestyle interventions and research aimed at modifying health behaviour among people with T2D, the most appropriate theory and practice strategies should be considered based on the problem, goals and environment. Employing the appropriate theoretical framework during design and implementation of behaviour change interventions can help identify and address factors that may be important determinants of intervention success or failure. Theories also help to inform decisions on the timing and sequencing of interventions for maximum effect [58]. Furthermore, backing interventions with sound theories enables one to explore why an intervention was or was not effective, making it more meaningful and useful.

1.5.0 Medical Nutrition Therapy and Type 2 Diabetes

Metabolic control, involving reduction of hyperglycemia, prevention of hypoglycemia in individuals on insulin treatment, and reduction of the risk of complications, especially cardiovascular disease, remains the central goal of diabetes management [75]. According to DC Clinical Practice Guidelines, MNT "can reduce glycated hemoglobin A1C by 1.0% to 2.0% and, when used with other components of diabetes care, can further improve clinical and metabolic outcomes". To this end, DC encourages people with diabetes to "choose the dietary pattern that best aligns with their values, preferences and treatment goals, allowing them to achieve the greatest adherence over the long term" [2]. As such, dietary strategies, which emphasize overall diet quality such as the Mediterranean diet, Canada's Food Guide, low glycemic index, moderately low carbohydrate, and vegetarian diets, are recommended. Balanced diets with a high composition of whole grains, fruits, vegetables, legumes, and nuts alongside moderate alcohol consumption and lower refined grains, red or processed meats, and sugar-sweetened beverages have been shown to improve glycemic control and blood lipids in patients with diabetes [40]. Key recommendations of the DC evidence-based nutrition therapy Clinical Practice Guidelines for promoting healthy eating behaviour among people with T2D also include reduction of dietary energy, fat and cholesterol intakes, increasing fruit and vegetable intakes, and choosing carbohydrate foods with low glycemic index [2]. Translating these recommendations into practical information for people with diabetes to increase knowledge, skills and self-efficacy is critical for achieving self-care dietary behaviour change. A nation-wide study examining diabetes mellitus status in Canada highlighted the persistent gaps associated with the treatment of T2D and showed that only 38% of people with T2D receive nutrition counseling from a registered dietitian [15]. Limited or no access to specialist nutrition services or RDs in many primary healthcare settings across Canada has also been reported [76]. Therefore, knowledge transfer that enhances nutrition knowledge and uptake of healthy eating behaviour, including low-GI concept, may be inadequate among adults with T2D.

1.5.1 Modes of Delivering Dietary Interventions

Diet related chronic diseases, including diabetes and cardiovascular disease, continue to place huge burdens on healthcare systems and governments. Various healthy eating and active living strategies have been implemented and evaluated for preventing and managing these diseases successfully [2, 42, 44, 77]. Effective modes of intervention delivery that have been used to deliver specific dietary strategies to optimize improvements in risk factors and reduce the risk of diet related diseases include: face-to-face contact, print, telehealth, and government policy and environment interventions [52, 78-82].

Face-to-face contact is the most common mode of dietary intervention delivery for people with established diet related chronic diseases. It is delivered directly to either individuals or groups, with or without additional modes such as telehealth (e.g. internet, phone contact) or print-based material [52]. Healthcare professionals including dietitians, nutritionists, nurses, physicians, exercise professionals or consultants, and trained interventionists often deliver face-to-face patient education sessions [52, 77]. For people with diabetes, the goal is to promote and support healthy eating patterns that emphasize a variety of nutrient dense foods in appropriate portion sizes, in order to achieve treatment goals and improve overall health outcomes. Usually, a face-to-face appointment with a registered dietitian or nutritionist results in the collaborative development of an individualized eating plans based on client preferences [2, 77, 83]. An annual follow-up encounter is often recommended to reinforce lifestyle changes as well as evaluate and monitor outcomes [77].

Print materials have been used either alone or to complement other intervention delivery modalities and are known to be an accessible and cost-effective means to provide repeated contacts necessary to promote both initiation and maintenance of behaviour change [82, 84, 85]. Print versions of dietary guidelines by government agencies, such as Canada's Food Guide [86], have also been made available to the general public or target populations in face-to-face contacts to enhance knowledge and uptake of healthy eating behaviours [2, 77]. Print materials that are tailored to specific diet and physical activity lifestyle change strategies are known to be more effective in promoting healthful lifestyle changes [82, 85].

Modern, non-face-to-face, telehealth-delivered dietary interventions are increasingly being used in isolation or with other delivery modes and have been shown to be very effective for prevention and management of diet related chronic diseases [79, 80]. Often referred to as broad-reach [84], telehealth lifestyle interventions may involve the provision of lifestyle education or advice to individuals or groups of individuals remotely via the telephone computer, and the Internet, videos, email, and/or mobile phone applications including text, photo messages (short message service (SMS), or multimedia message service (MMS)) [80, 84, 87-94]. Telehealth is defined as the delivery of healthcare services at a distance, using information and communication technologies to exchange health information [80, 87]. While this definition by the World Health Organization encompasses telemedicine, the distinguishing feature of telemedicine is that it is restricted to healthcare delivery by physicians only [87]. Telehealth services can be provided by any health professional and can include synchronous (i.e. same time, different location) or asynchronous (i.e. different time, different location) patient education, counseling, and remote monitoring [80, 87].

Population level policy and environment interventions play a major role in diet related disease prevention and management [81]. For example, population education approaches such as national dietary guidelines, mass media campaigns, use of cultural influencers as well as school curriculums focused on nutrition and culinary skills are proven delivery modes for some dietary intervention strategies [95]. Government regulated point-of-purchase labeling policies, which include mandatory food package nutrition fact panels, health claims, restaurant calorie menu labeling, front-of-pack traffic light, and warning labels are other approaches used in delivering dietary interventions [95]. Another effective policy approach is industry quality standards such as mandatory or government recommended limits and standards on use of additives, including trans fat, salt, sugar, and food fortification [81]. Fiscal incentives and disincentives such as national soda and junk food taxes, subsidies for fruits and vegetables in national food assistance programs and agricultural incentives are other modes of delivering specific dietary intervention strategies. Most of these approaches influence the food environment within which the individual lives [81, 95].

1.5.2 Dietary Interventions Used During Dietitian Consultations for People with Diabetes

Medical nutrition therapy guidelines recommend various strategies for healthful eating and attaining blood glucose control for optimal health outcomes for people with diabetes. These may include evidence-based strategies such as the Mediterranean, the Dietary Approaches to Stop Hypertension (DASH), vegetarian, and GI dietary patterns. Good understanding of these approaches, combined with motivation, encourages consumption of combinations of different foods or food groups based on personal preferences as determined by culture, religion, health beliefs and goals, economics [3, 4]. Besides guideline strategies, various meal planning approaches, including the exchange (list) system, carbohydrate counting, and the plate method, discussed below, have been taught during face-to-face MNT patient consultations to help guide people with diabetes in making healthy food choices for optimal blood glucose control [96, 97].

The exchange system was first published in 1950 to address meal planning problems for people with diabetes by grouping foods with similar distributions of carbohydrate, protein, fat and calories so that foods within the same group could be exchanged [98]. The food exchange lists were meant to provide a structured system that incorporates consistency in meal planning and help people with diabetes to include a wider variety of foods in their diets [96]. One serving in a category is called an “exchange” or "choice." For example, carbohydrate exchanges are 15g per portion and an individual can choose to eat half of a large ear of corn or 1/3 cup of cooked pasta for one starch choice. Though the exchange system has been shown to work well in in helping people with diabetes regulate their blood glucose concentrations, it takes time to become familiar with which foods belong on which lists and to recognize their portion sizes. The exchange system has been taught as the standard meal planning tool for people with diabetes and erroneously perceived as the “diabetic diet” until the rise of the carbohydrate counting approach [96, 98].

Essentially, carbohydrate counting, involves keeping track of the amount of carbohydrate foods eaten at meals and snacks. It is based on the premise that dietary carbohydrate is the primary nutrient with the greatest impact on postprandial blood glucose concentration [96, 99]. As such, dietitians teach people with diabetes to eat about the same amount of carbohydrates each day at regular intervals depending on the diabetes type, literacy and numeracy skills. Carbohydrate counting, which gained popularity after the Diabetes Control and Complications Trial [54], has been shown to be safe and improves quality of life, reduces BMI and waist circumference as well as improve HbA1c among adult patients with type 1 diabetes [55]. Three levels of carbohydrate counting exist, based on increasing levels of complexity. Level 1, or basic carbohydrate counting, introduces clients to the concept of carbohydrate counting and focuses on carbohydrate consistency. Level 2, or intermediate, focuses on the relationships among food, diabetes medications, physical activity, and blood glucose level and introduces the steps needed to manage these variables based on patterns of blood glucose levels. Level 3, or advanced, is designed to teach clients with type 1 diabetes who are using multiple daily injections or insulin infusion pumps how to match short-acting insulin to carbohydrate using carbohydrate-to-insulin ratios [96]. To do this more effectively, users of this approach need to know how to measure food portions and become educated readers of food labels, paying special attention to serving size and be able to adjust insulin dose to match carbohydrate content of meals [96].

The plate method, a relatively newer approach, uses a simple, stepwise method of meal planning that shows the proportions of each food category that are appropriate for a healthy, balanced diet [100]. In using the plate method, people with diabetes are advised to fill one-half of their plate with non-starchy vegetables, such as spinach, carrots and tomatoes when preparing their plates. One-quarter is then filled with a protein, such as tuna or lean pork and the last quarter with a whole-grain item or starchy food. Finally, a serving of fruit or dairy and a drink of water or unsweetened tea or coffee is the added. This approach works well for patients who have poor math or reading skills, or have language difficulties [97, 100].

The exchange system and carbohydrate counting are more established in clinical practice while the plate method is relatively new [101]. Closer observation of these and other approaches that are taught to people with diabetes during MNT by registered dietitians reveals the focus on consistency of carbohydrate quantity in meal planning without an objective measure of its quality. However, as the body of research supporting the GI concept has shown, the type of carbohydrate has equally strong influence on blood glucose control besides the amount [11, 40]. The GI concept, unlike the guideline approaches, provides an assessment of the quality of carbohydrate containing foods based on their ability to raise blood glucose concentration [11]. Besides offering an objective measure of carbohydrate quality, GI also provides a physiological basis for meal planning approaches [11]. For example, to decrease the glycemic response to dietary intake, low-GI foods are exchanged for high GI carbohydrate foods. This encourages consumption of combinations of different foods or food groups based on personal preferences without weighing or measuring foods, using exchanges, or counting calories, fat or carbohydrate [3, 4, 97].

Given that there is no "one-size-fits-all" diet or meal planning approach for achieving metabolic goals, it is important to provide comprehensive education and to support people with diabetes in choosing dietary interventions that work best to for them. However, while meal planning approaches have received more prominence in clinical practice, controversies surrounding the use of the GI concept continue to hinder its translation and uptake among people with diabetes. To this end, it is important to help patients acquire adequate GI knowledge and related food-based skills for improving dietary self-management.

1.5.3 Diabetes and the Glycemic Index Concept

Dietary carbohydrates are important sources of energy, fibre, vitamins and minerals. However, the types and quantities of carbohydrates can impact blood glucose concentration differently when consumed [21, 22]. This property of carbohydrates, first reported by Jenkins and colleagues in the early 1980s [11], ranks a given dietary carbohydrate based on its immediate impact on postprandial blood glucose concentration [21]. Specifically, the GI is defined as the change in postprandial blood glucose concentration produced by consuming a portion of food containing 50 g (or in some cases 25 g) of available carbohydrate expressed as a percentage of the change in blood glucose concentration elicited by 50 g (or 25 g) of the reference carbohydrate, usually glucose solution or white wheat bread [10]. Depending on the referent food, GI can be measured on the glucose or the bread scale. Foods containing carbohydrate that are digested, absorbed and metabolized quickly are considered high GI (GI ≥ 70 on the glucose scale) whereas those that are digested, absorbed and metabolized slowly are considered low-GI foods (GI ≤ 55 on the glucose scale). The GI, expressed as an index or percentage, is a property of a given food and an objective measure of carbohydrate quality [10, 101]. Using the GI and portion size of a given food, glycemic load (GL), a composite measure of carbohydrate quality and quantity, can be calculated to predict blood glucose response to a specific type and amount of a dietary carbohydrate [23]. Glycemic load is defined as the product of GI and the total available carbohydrate content in a given amount of food (i.e. GL = GI x available carbohydrate per given amount of food). Available carbohydrate, which is the portion of food that is digested, absorbed and metabolized as carbohydrate, can be expressed as gram (g) per serving, g per 100 g food, g per day’s intake, and g per1000 kJ or 1000 kcal and serves as the corresponding unit of GL depending on the context in which it is used [10, 101, 102]. Consuming lower GI foods produces lower glycemic responses, reduces insulin demand and is beneficial for metabolic control in diabetes management [24]. Adoption of the low-GI dietary pattern as part of an overall healthy eating lifestyle has been shown to significantly improve glycemic control, cardiovascular risk factors (e.g. total cholesterol, HDL), beta cell function and decreased need for anti-hyperglycemic agents among individuals with diabetes [39, 40, 103-111]. Hence, equipping people with T2D with sufficient GI concept knowledge and self-efficacy through GI-targeted education that focuses on foods and skills development may therefore improve overall dietary self-care practices and health outcomes.

1.5.4 Evidence for GI Concept in Diabetes Management

The benefit of a relatively lower glycemic response following consumption of low-GI dietary carbohydrates forms the basis for the evidence-based guide for carbohydrate-based food selection for people with diabetes [101, 112]. Despite the available body of evidence however, relevance of the GI concept has historically been fraught with controversies since it was defined by Jenkins [12]. Proponents of the GI concept endorse it as a robust quantitative predictor of relative postprandial glycemic response of foods and a qualitative predictor of carbohydrate quality among diabetes patients [11, 113]. Others have studied the benefits of GI for obesity, diabetes, and markers of cardiovascular disease. For instance, a meta-analysis of randomized controlled trials examining the effects of low-GI or GL diets for weight loss in overweight or obese individuals showed significantly greater decrease in body mass, total fat mass, body mass index, total cholesterol and low density lipoprotein (LDL)-cholesterol compared with high GI diets. It was concluded that lowering the GL of the diet appeared to be an effective method of promoting weight loss and improving lipid profiles and could be simply incorporated into a person's lifestyle [114]. A meta-analysis of randomized controlled trials has shown that low-GI diets reduced A1c by 0.43% (CI 0.72-0.13) over and above that produced by high GI diets [103]. Another study assessed randomized controlled trials of four weeks or longer that compared a low-GI, or low GL diet with a higher GI or GL or other diet for people with either type 1 or 2 diabetes mellitus, whose diabetes was not already optimally controlled. It found that low-GI diet can improve glycemic control in diabetes without compromising hypoglycemic events [115].

The one-year controlled trial of low-GI dietary carbohydrate in T2D, the Canadian Trial of Carbohydrates in Diabetes (CCD), compared the effects of altering GI or the amount of carbohydrate on glycated hemoglobin (HbA1c), plasma glucose, lipids, and C-reactive protein (CRP) in people with T2D. Participants (n=162) were randomly assigned to high carbohydrate, high GI, high carbohydrate, low-GI, or low carbohydrate, high monounsaturated fat (low CHO) diets for 1 year. Findings show that body weight did not differ between diets and long-term HbA1c was not affected by altering the GI or amount of dietary carbohydrate. However, sustained reductions in postprandial glucose and CRP were observed [106].

In summary, there is considerable evidence showing that adopting a low-GI dietary pattern as part of a healthy eating lifestyle has benefit for significantly improving cardiovascular risk factors (e.g. total cholesterol, HDL), glycemic control, postprandial glycemia, beta cell function and decrease the need for anti-hyperglycemic agents among individuals with diabetes [39, 40, 103-111]. The GI concept is also an effective and sustainable tool for enhancing overall diet quality and knowledge by improving quality and variety of dietary carbohydrates consumed [14, 109, 116-118].

1.6.0 Health Services Delivery: Registered Dietitians, Management of Type 2 Diabetes, and GI Concept

Diabetes educators, especially Registered Dietitians (RD) play a vital role in translating relevant nutrition research knowledge, such as GI concept, for uptake and application among patients. Health care professionals, including RDs, are however divided on using the GI concept in educating patients with diabetes in Canada. Many diabetes patients do not receive routine GI-targeted nutrition education as part of their diabetes management care [14, 119]. Meanwhile, less than 40% of RDs working with diabetes patients include low-GI eating in their nutrition education [18, 19]. These suggest inadequate translation of the GI concept into practical information for enhancing knowledge, skills, and self-efficacy for dietary self-care behaviour change.

Underlying reasons for the existing debates and differences concerning the use of the GI concept in nutrition education include barriers such as inadequate information and tools for healthcare professionals, as well as errors in understanding and interpretation of available evidence by some healthcare professionals. RDs in Canada have cited a lack of knowledge or the complexity of the GI concept for teaching, and a perceived difficulty for their clients to learn, and inadequate teaching tools [18, 19]. More than half (57%) of non-users of GI cited complexity of the concept for patients to understand, lack of teaching tools (46%), and lack of knowledge on the part of RDs on how to teach the GI concept to clients as barriers for their non-use of GI concept in advising T2D patients [19]. In their review, Grant and colleagues refuted these perceived barriers to GI concept application among RDs in Canada [18]. They made references to the print and online versions of the Dietitians of Canada (DoC) GI concept educational tool and the DC Clinical Practice Guidelines [2] as available resources while advocating GI-based dietitian centered education manuals, special in-service training for dietitians, and further research to address perceived barriers and knowledge gaps for translating the GI concept more effectively [18]. Notwithstanding Grant and colleagues' reference to available resources [18], the number of T2D patients receiving GI concept education several years later has remained relatively the same. For example, in a more recent physical activity and dietary observational study among a sub sample of the Alberta's Caring for Diabetes (ABCD) cohort of individuals (N=170) with T2D in Alberta, about 44% men and 37% women of indicated that they did not know about GI [17]. This lends support to the persistence of limited access to GI-targeted dietary advice and reported barriers and differences among healthcare professionals' inclusion of GI in patient education [15, 18, 19].

The passive attitude towards promoting the GI concept for diabetes management in Canada could also be linked to existing debates around its clinical usefulness. This view is supported by a recent opinion of Health Canada that "the inclusion of the GI value on the label of eligible food products would be misleading and would not add value to nutrition labeling and dietary guidelines in assisting consumers to make healthier food choices" [13]. A rebuttal from leading GI and nutritional epidemiology authorities at the International Carbohydrate Quality Consortium clarified some of the misconceptions regarding Health Canada's position on the accuracy and precision of the GI evidence [120]. However, Health Canada's position could be a suggestion as to why some health professionals' choose not to use GI-related concepts and resources when working with their clients. Furthermore, a formal assessment of five GI education materials, including Diabetes Canada's "the Glycemic Index" concluded on a "Not Suitable" final suitability rating. The authors suggested that the non-suitability of these GI teaching materials could be contributing to health professionals' perceptions and use of the GI concept in client education. Development of suitable, simple written GI education materials may be needed for better uptake and use among dietitians [121].

Upholding high quality evidence is fundamental to effective evidence-based practice and policy formulation since, "clinical guidelines are only as good as the evidence and judgments they are based on" [122]. Concerns about the accuracy and precision of GI methodology, consistency of findings, clinical significance of effect size on glycemic control (A1c), and overall clinical utility of the GI concept have been raised [12, 13, 113, 123, 124]. However, allowing "perfect to be the enemy of good" by using study design hierarchy to solely define study quality and grade overall strength of evidence without compromises and reference to other information regarding GI benefits is not recommended [120, 122].

Limitations of current GI evidence notwithstanding, equally good and compelling evidence from systematic reviews show a clear trend of outcome benefit of low-GI eating [114, 115] including reductions in HbA1c from 0.43% to 0.6% [103, 115]. Although this benefit appears modest, it is comparable to the 0.5% reductions in HbA1c usually achieved using alpha-glucosidase inhibitors like acarbose [12, 125]. Moreover, promoting low-GI eating as a supplement to usual nutrition care is considered an effective tool for enhancing overall nutritional quality and knowledge because it improves the quality and variety of dietary carbohydrates consumed [14, 109, 116, 117]. Teaching the GI concept is certainly worth considering given that it offers additional benefits on top of conventional MNT. Failure to advocate for comprehensive use of GI among health professionals, despite its inclusion in the clinical guidelines, may be depriving people with diabetes of the full benefits of nutrition therapy. Therefore, until scientifically rigorous enquiries accumulate enough evidence to successfully address existing controversies, available evidence regarding the benefits of adopting GI should be given due consideration. And, while we wait for the "perfect" evidence, health professionals should be well resourced and encouraged to effectively translate the "good" aspects of current GI evidence for the additional benefits it confers beyond conventional MNT alone.

1.7.0 Dietary Assessment in Type 2 Diabetes Research and Practice

Determinants of adequate nutrition and T2D have been effectively studied and dietary guidelines developed to ensure healthy eating at the individual and population levels. Lifestyle, physiological, diet-related, and environmental factors however interfere with adherence to healthy eating recommendations. As such, measuring dietary intakes of individuals with diabetes is important for addressing dietary factors influencing diet-disease relationships. Principal methods used in collecting summary dietary intake information from individuals and populations for decision-making in research and practice include 3-day food records (3-DFR), 24-hour dietary recall (24-HDR), and food frequency questionnaires (FFQ).

1.7.1 Diet Record (3-Day Food Record)

A diet record, also known as food record or diary, is a prospective dietary assessment method that measures individual's current dietary intakes over a specified period of time [126, 127]. While the food record method can be used to obtain an estimate of habitual dietary intake for one or more days, three days are widely accepted and used to account for day-to-day variability in food intakes, to reduce respondent burden (known to decrease reported intakes) and processing costs of food intake data [126, 128]. In a 3-DFR, individuals are asked to record, in as much detail as possible, all foods and beverages consumed over a 3 days period (usually 2-week days and 1-weekend day). Details recorded at the time of food consumption include estimates of portion sizes and descriptions of how food is prepared. Portion sizes may be measured using common household items such as scales, drinking glasses, measuring jugs and spoons or estimated using photographs showing sample portions sizes of foods measured against items including a finger, palm of a hand and a hockey puck or food models. The food record information are then analyzed and converted to estimates of daily food/food groups or mean daily nutrient intakes using food composition tables.

Food records of highly motivated and well-trained respondents have a high potential for providing accurate quantitative information on foods eaten during the recording period [126, 129]. Since foods eaten, their detailed descriptions, and quantities are record directly during meals; memory limitations are not a source of error in the 3-DFR compared with recall methods. Energy expenditure assessed by food record and doubly labeled water has been compared with accurate food record dietary intake data reported among highly motivated participants [130]. As such, the food record method is often regarded as the "gold standard" against which other dietary assessment methods, such as the FFQ, are validated for use in primary data collection [126, 129, 131].

Possible sample selection bias, due to the need for literate, numerate, and motivated individuals; dietary intake measurement bias caused by the inconvenience of recording and selective reporting of foods easy to record; and social desirability bias towards perceived healthy foods are some of the drawback of the 3-DFR method [126, 129]. Participant training and provision of verbal and written instructions for keeping food diaries have been suggested for enhancing compliance and improving participant’s ability to provide detailed and accurate food intake information. Encouraging respondents to maintain usual dietary practices during the period, and record foods as they are consumed also increases the accuracy and reliability of food records. While the above strategies can significantly reduce random error, they can equally increase overall costs [129].

1.7.2 24-Hour Dietary Recall

The 24-HDR is a retrospective measure of an individual's past dietary intake during the previous 24 hours (day). Usually, an adequately trained interviewer, preferably a dietitian, equipped with a standard instrument to ask unbiased probing questions in person or by phone, conducts 24-HDR. Respondents are asked to recall (remember and report) all foods and beverages consumed in the previous 24 hours with thorough descriptions and quantity estimates of foods, which are then recorded using a paper-and-pencil form or directly into a computer [129, 132, 133]. On average, a 24-HDR takes between 30-60 minutes to complete, with its detail and accuracy highly dependent on interviewer probes and reported portion size estimates [126, 134]. Interviewers may use food models, household items and photographs to assist respondents with food quantification. Dietary recall data are then analyzed using nutrient files to produce dietary intake estimates that are often used to represent usual intakes of respondents.

A 24-HDR food intake data collected from individuals without any memory impairment by a well-trained interviewer using a structured instrument and with specific unbiased probing questions are considered quantitatively and qualitatively accurate. Single 24-hour recalls are considered quick, easy, and inexpensive in a sense; with low respondent burden and potential for covering large numbers of individuals [129, 134]. Recall bias, due to memory limitations is recognized as a major disadvantage that introduces random error into 24-HDR dietary data. Hence, it renders the 24-HDR inappropriate for collecting dietary intake data from certain individuals/population subgroups with cognitive impairment. Well-trained interviewers, skilled in asking specific probing questions, can however help participants to remember what they consumed [129]. Day-to-day variations in dietary intakes and omission of infrequently eaten foods make a single day's food intake data unrepresentative for describing usual intakes; while estimates of reliability for major nutrients measured using 24-HDR are also known to be discouraging [134-136]. 24-HDR can be repeated to smooth out daily variations and improve precision, however, costs of interviewers and dietary data processing soon add up to make the 24-HDR a relatively more expensive method for assessing usual intakes [132].

1.7.3 Food Frequency Questionnaires

Food frequency questionnaires are retrospective measures of past intakes for estimating usual food consumption patterns over extended periods of time. Whether qualitative (i.e., without questions on portion size estimates), quantitative (i.e., includes questions on portion size), or in between, FFQs generally have two components: a food list, which may focus on specific groups of foods/nutrients, and a set of frequency-of-use categories for respondents to report how often foods were consumed. Besides questions on quantity, some FFQs include also include sections on composition/varieties of foods the same food [132, 134, 137].

The underlying principle of FFQs as a measure of dietary intakes is that, average long-term diet, (e.g., intake over weeks, months, or years) is a theoretically more important exposure than food intakes over a few specific days [137]. As such, the FFQ tends to collect more crude dietary data (which is considered more representative of typical food intakes over an extended period of time) at the expense of relatively more precise intake estimates using 3-DFR or 24-HDR methods. Therefore FFQ dietary intake estimates are best used for ranking individuals according to intake [132, 134, 137]. The FFQ dietary assessment method derives its strength and preference for use in large-scale surveys from the weaknesses of short-term recall and diet record methods. Comparatively, FFQs have low respondent burden and are generally easier and cheaper to administer and process. A major weakness of the FFQ however, is its poor accuracy due to measurement bias as a result of an inadequate listing of possible foods (systematic error) or errors in estimating consumption frequency and/or portion sizes. Selective reporting of foods also increases social desirability biases in FFQ data [138, 139]. Besides, FFQs require validation in relation to a reference method such as the 3-DFR; and in cases where they are self-administered, respondents' literacy and numeracy skills are be crucial [132, 134, 137].

1.7.4 Choice of Dietary Assessment Methods

The choice of appropriate dietary assessment methods for research and practice depends on key factors such as the level of accuracy, time period required, type of dietary information needed (i.e., foods, nutrients, other foods constituents or dietary behaviour), resource constraints (time, money staff and respondent characteristics), and scope of interest (individuals versus groups; and total versus relative intakes) [132, 140]. Comparisons of 3-DFR, 24-HDR and FFQs regarding the choice of method for research and practice are based on their characteristics discussed above.

Regarding accuracy, multiple days' food records, such as the 3-DFR, are considered to be the "gold standard" for collecting mean dietary intake data of individuals. A 3-DFR is most appropriate for interventions in which the expected effect is small and thus requires a more accurate measure of dietary intakes and those aimed at enhancing and measuring dietary behaviour change. The 3-DFR allows a broad assessment of dietary factors and offers flexibility with food intake data analysis, providing rich, detailed estimates of daily food groups, foods and mean daily nutrient intakes for dietary investigations into incidence and endpoints of many diseases over time. However, food record data processing can be very labour intensive, resulting in higher personnel costs and increases errors. As such, they are most suitable for relatively small to medium scale prospective cohort population interventions involving literate, highly motivated individuals [132, 134, 137, 141].

Unlike the 3-DFR, trained interviewer administration of the 24-HDR makes it most suitable for use among population subgroups such as children, low socioeconomic status individuals, and some elderly groups [126, 129]. Although single 24-HDRs are less representative of usual intakes, they provide quick and more accurate mean intake estimates for comparing large populations compared with FFQs. Multiple 24-HDRs are however best suited for relatively small to medium studies due to cost implication associated with processing large quantities of 24-hour recall data.

Dietary intakes derived from FFQs are considered the least accurate, with FFQs often requiring validation in relation to a reference method such as the 3-DFR or 24-HDR. However, large population interventions rely heavily FFQs because they are representative of usual intake and easier for self-administration by respondents; with processing readily computerized thereby considerably reducing costs compared with 3-DFR and the 24-HDR. Besides, the 3-DFR and 24-HDR, used to obtain information on current diet, are unsuitable for case-control studies that require past dietary intakes before the onset of the outcome of interest. Modified versions of FFQs known as screeners, with reduced and more focused food lists are good for rapid assessment of individuals' usual dietary intakes for practice and for grouping respondents in large population interventions which do not require estimates of total diet, and hence full-length FFQs [132, 137, 142].

In summary, methodologically sound assessment and reporting of dietary intakes of individuals and populations are important for research and practice, however, there is no perfect measure of dietary intake. Although 3-DFR, 24-HDR, and FFQ are considered subjective self-report measures, with inherent limitations that can affect estimates of dietary intakes [143, 144], understanding their features is helpful for selecting the most appropriate method based on the purpose/research question being investigated, respondent characteristics, and available resources.

1.8.0 Summary

Living with diabetes requires lifestyle choices that positively impact many health-related outcomes. Lifestyle interventions, including healthy eating and physical activity, are advocated for managing diabetes and preventing its long-term complications. Evidence-based DC guidelines recommend consuming low-GI foods as part of a healthy diet for people with diabetes. Registered dietitians' role in effectively equipping diabetes patients with sufficient nutrition knowledge, including GI concept, is fundamental to increasing efficacy for dietary self-care and improved health outcomes. Since patients make a large majority of their health-related decisions outside the clinic setting on a daily basis, it is important to assess current practices and provide necessary tools to support them by developing and evaluating promising, effective interventions that augment current practice. In addition to understanding efficient and cost effective patient-centered approaches to delivering nutrition self-management support, this line of research may contribute to the body of evidence regarding the GI concept and policy around its use.

1.9.0 Aims and objectives

The overarching aim of this research was to capture current dietary behaviours, design, implement, and evaluate the effectiveness of an enhanced, web-based GI-targeted nutrition education intervention aimed at bridging the GI concept knowledge translation gap for improving dietary and clinical outcomes for people with T2D. The individual objectives of each study were:

Study #1: To examine diet-related care practices among adults with T2D with a focus on GI choices.

Study #2: To examine sex differences in GI knowledge and intake among individuals with T2D

Study #3: To examine the effectiveness of a web-based GI-targeted nutrition education program on dietary intakes among adults with T2D.

Study #4: To examine computer proficiency and web-based lifestyle intervention use among older adults with T2D.

1.10.0 Hypotheses

We hypothesized that enhancing GI concept knowledge and self-efficacy will lead to low-GI dietary behaviour change for improved diet quality and health outcomes for people with T2D. The specific hypotheses for this research program were:

Study #1: We hypothesized that people with T2D who self-reported dietary practices consistent with diabetes self-care dietary recommendations for most days per week (i.e., ≥5 days) would also report dietary intakes that reflect those practices and better glycemic control.

Study #2: We hypothesized that people with T2D who reported having good GI concept knowledge would report GI intakes consistent with their knowledge and stage of readiness for GI behaviour change. We also hypothesized that males would have less GI concept knowledge and higher GI intake.

Study #3: We hypothesized that adults with T2D who receive GI-targeted nutrition education will increase intake of low-GI foods by improving knowledge and self-efficacy to include low-GI foods in their daily meal planning.

Study #4: We hypothesized that older adults with T2D who were recruited to participate in a lifestyle intervention targeting the GI concept would have low computer proficiency.

1.11.0 Thesis overview

The first two studies (Chapters 2 and 3) used secondary data from the Healthy Eating and Active Living for Diabetes in Primary Care Networks (HEALD-PCN) and the Alberta Caring for Diabetes (ABCD) cohort nutrition and physical activity sub-study. Both studies were carried out to assess current dietary practices of people living with diabetes in Alberta as it pertains to the GI concept. Data from both studies informed the design and evaluation of a pragmatic clinical trial to examine the effectiveness of a 12-week web-based targeted nutrition education program on GI dietary behaviour and intakes among older adults with T2D living in Edmonton, Alberta. Findings from the clinical trial regarding GI related dietary behaviour change and intakes are reported in Chapter 4. This chapter shows that well designed and executed lifestyle interventions that use emerging and widely accessible information technologies can bridge existing knowledge gaps in supporting people with T2D for improved health outcomes. Results from the baseline computer proficiencies of those participating in the clinical trial are described in Chapter 5. This chapter provides information about how prepared this population of older adults is for web-based lifestyle interventions aimed at improving their daily diabetes dietary habits. These data explain the impact of computer proficiency on the effectiveness of the web-based HEALD-GI trial (i.e., low proficient may be less successful). The protocol for the clinical trial, which was invited for publication upon receipt of grant funding and registration on the ClinicalTrials.Gov has been developed into a full manuscript and included as an Appendix.

In summary, this body of research regarding the dietary practices, specifically; the GI concept uptake provides a useful framework that can be adapted to similar lifestyle interventions in providing care and support for people living with diabetes and other chronic diseases.

CHAPTER 2

Examining Diet-Related Care Practices Among Adults with Type 2 Diabetes: A Focus on Glycemic Index Choices

2.1.0 Abstract

We examined self-care dietary practices and usual intakes among adults with type-2 diabetes in Alberta, Canada; using data from the Healthy Eating and Active Living for Diabetes (HEALD) study. Participants completed a modified Fat/Sugar/Fruit/Vegetable Screener and answered questions about the number of days/week they followed specific diabetes self-care dietary recommendations. Capillary blood samples were collected to assess glycemic control measured by hemoglobin A1c. ANOVA was used to examine differences in dietary self-care, intakes, and glycemic control across categories of days/week of practicing recommended dietary behaviour. Participants (N=196) were 51% women, mean age 59.6 (8.5) years, with mean BMI 33.6 (6.5) kg/m^2, and diabetes duration of 5.1 (6.3) years. Sixteen percent of participants were unfamiliar with low-GI eating and 28% did not include low-GI foods in their diet. Overall, lower mean intake of saturated fat, trans fat, added sugars, higher fiber, and greater GI were each associated with meeting diabetes-related dietary behaviours including: eating ≥ 5 servings of vegetables and fruit; avoiding processed high fat foods; and, replacing high with low-GI foods ($p < 0.05$). No clear pattern was observed for low-GI eating and A1c.

Note: A version of this chapter was previously published as: Avedzi H, Mathe N, Bearman S, Storey K, Johnson JA, Johnson ST. Examining dietary practices among adults with type-2 diabetes: a focus on low glycemic index choices. Canadian Journal of Dietetic Practice and Research 2017;78(1):26-31. PMID: 27779892.

2.2.0 Introduction

Evidence-informed nutrition therapy and counseling for people living with type-2 diabetes has been shown to improve glycemic control, clinical and metabolic outcomes, and reduce hospitalization [6-9]. Dietary recommendations for people with type-2 diabetes suggest replacing high glycemic index (GI) with low-GI carbohydrate foods may improve glycemic control and cardiovascular risk factors such as total cholesterol [103, 104].

Few studies have examined salient diabetes-related dietary behaviours and usual intakes among adults living with type-2 diabetes using two separate measures. Hence, the study objectives were: 1) to describe diabetes-related dietary self-care activities using a previously validated tool; 2) to link those practices with usual dietary intakes among adults living with type-2 diabetes using a food frequency questionnaire; and, 3) to examine the relationship between self-reported dietary practices and relevant diabetes-related biomarkers.

2.3.0 Methods

2.3.1 Study Population and Setting

A total of 196 adults with type-2 diabetes who participated in the HEALD study (October 2009 to January 2013) [74] were included in this pooled analysis. Briefly, HEALD was a pragmatic controlled trial designed to evaluate implementation of a novel, evidence-based physical activity and dietary self-management program for type-2 diabetes patients within a Primary Care Network environment in Alberta, Canada. The University of Alberta Health Research Ethics Board granted study approval (Study number: Pro00008427) and all participants provided written informed consent. HEALD was registered (October 7, 2009) with ClinicalTrials.gov identifier: NCT00991380.

2.3.2 Diabetes Self-care Dietary Practices

Diabetes-related dietary practices were measured using the previously validated Summary of Diabetes Self-Care Activities (SDSCA) [145]. The SDSCA is a brief self-report instrument for assessing various aspects of the diabetes self-care regimen: general diet, specific diet, exercise, blood-glucose testing, foot care, and smoking [145]. SDSCA specific self-care dietary practice items included in these analyses were: (a) "Have you eaten five or more servings of vegetables and/or fruit (VF)?" and (b) "Have you eaten high fat foods such as processed meat or full-fat dairy products?" In addition to the SDSCA items, a new item (c) "Have you followed an eating plan that includes low-GI foods?" was included. Responses for all questions ranged from 0 to 7 days. Using the SDSCA scoring scales [145], mean number of days/week of practicing specific dietary behaviours was calculated for study objective one. As recommended [145], responses for the question (b) "Have you eaten high fat foods such as processed meat or full-fat dairy products?" were reversed (i.e., 0=7 and 7=0). Scores for questions (a) and (b) were averaged to generate a composite specific diet score for "≥ 5 servings of VF" and "avoided high fat foods such as processed meat or full-fat dairy products". The mean number of days/week participants included low-GI foods in their diets was calculated similar to SDSCA scoring scale [145]. Primary outcome was number of days/week of practicing specific dietary behaviours and dietary intakes, GI, GL, and clinical measures constituted secondary outcome measures.

2.3.3 Dietary Intakes, Glycemic Index, and Glycemic Load

For study objective two, dietary intakes, GI, GL were used. Diet was assessed using Block Fat/Sugar/Fruit/Vegetable Screener (Block Screener), a validated food frequency questionnaire (FFQ) for estimation of usual dietary intakes of fats, sugars, fruit and vegetable and GL and GI [146-149]. The 55-item tool included portion sizes for 32 food items to assist in estimating quantities of foods and beverages consumed and a series of "adjustment" questions about usual intakes of low-fat/trans-fat free or low-carbohydrate/low-sugar versions of foods [150]. The screener was modified to suit the Canadian population by replacing American foods with brands specific to Canada.

Dietary intake data were analyzed by NutritionQuest® (Berkely, California, USA) to produce estimates of saturated fat, trans fat, total sugars, "added sugars" (in sweetened cereals, soft drinks, and sweets), fruit and fruit juice, vegetable intake, GL and GI [150]. Daily average GI was calculated by totaling the GI ratings of all carbohydrate-containing foods identified from each day from the Block Screener using published international tables with additional information retrieved from an online database (Average GI = (Sum (GI value of each food)/Number of GI-rated foods)) [150, 151]. Glycemic load (GL) was calculated as GI/100 x Net Carbohydrate (g) (where Net Carbohydrates are equal to the total carbohydrates (g) minus dietary fiber (g)).

2.3.4 Clinical and Physical Measures

Clinical and physical measures were used. Fasting capillary blood samples were collected to assess A1c (DCA Vantage) and lipid profile (Cholestech LDX). Resting heart rate and blood pressure (BP) were collected (BPTru). Smoking status was determined by questionnaire. Weight, height, and waist circumference were measured and body mass index (BMI) calculated as kg/m^2 [74].

2.4.0 Statistical Analyses

Descriptive analyses were completed for demographic and clinical data. Categories for the dietary practice item “Consumed ≥ 5 servings of VF and avoided processed high fat foods” (days/week) were: 0-3, 4, 5, 6-7 and for “Followed low-GI eating plan” (days/week) were: 0, 1-2, 3-4, 5-7. Mean intakes for total calories, total, saturated, and trans fats, and protein, total sugar, added sugar, fruit, vegetables, fibre, and mean GI, GL and HbA1c were compared across the dietary practices categories using one-way ANOVA. Pairwise comparisons of means were carried out using Tukey’s post hoc test where one-way ANOVA suggested statistically significant differences between group means of dietary intakes and clinical measures. P-values <0.05 were considered significant. All statistical analyses were performed using STATA (version 12.1, StataCorp, College Station, Texas, USA, 2012).

2.5.0 Results

2.5.1 Participant Characteristics

The 196 participants (mean age 59.6 (8.4) years) were 51% female, 94% Caucasian with mean diabetes duration 5.1 years (Table 2.1). Overall, the sample had a good metabolic profile with mean BMI of 33.6 (6.5) kg/m^2, mean systolic blood pressure of 125.6 (16.3) mmHg and A1c of 6.8 (1.1)% (Table 2.1).

2.5.2 Diabetes Self-care Dietary Practices

Eighty-three percent of respondents reported consuming ≥ 5 servings of VF and avoiding processed high fat foods for ≥4 days/week. Respondents adopting low-GI eating behaviour included low-GI foods in their diets for approximately 3 days/week. Twenty-eight percent (n=55) did not include low-GI foods in their eating plan and another 16% (n=33) reported being "unfamiliar" with the low-GI concept and were grouped together with those who reported consuming a low-GI diet for 1-2 days/week because there was no significant difference in their demographic and clinical characteristics.

2.5.3 Estimated Dietary Intakes, Glycemic Index, and Glycemic Load

Those consuming ≥ 5 servings of VF and avoiding processed high fat foods also reported lower intakes of total, saturated, and trans fats, and added sugars across categories with increasing days/week ($p<0.05$) (Table 2.2). A total of 14.5g of total fat, 6g of saturated fat, and 2.3g of trans fats were avoided per day among those consuming ≥ 5 servings of VF and avoiding processed high fat foods for 6-7 days/week compared with 0-3 days/week ($p<0.05$). Estimated mean servings of VF per day increased across categories and individuals who consumed ≥ 5 servings of VF and avoided processed high fat foods for 6-7 days/week consumed two more servings of VF per day compared with 0-3 days/week. Self-reported inclusion of low-GI foods on more days/week was consistent with lower intakes of saturated fat, trans fat, and added sugar ($p<0.05$) (Table 2.3).

Differences in mean GI intake were seen across categories. Participants who reported eating ≥ 5 servings of VF and avoided processed high fat foods for 6-7 days/week had the lowest GI intake compared with 0-3 days/week (49.8 ± 4.1 versus 53.7 ± 3.5; $p<0.01$) (Table 2.2). Increasing number of days/week of consuming ≥ 5 servings of VF and avoiding high fat foods showed an estimated mean difference of 2.0 to 3.9 in GI ($p<0.05$) between categories. Differences in estimated mean GI intake were seen among individuals who reported including low-GI foods in their diets ($p<0.05$). Compared with those who made less frequent low-GI choices, individuals who reported more frequent weekly low-GI choices showed an overall lower mean GI intake (50.7 ± 4.4 versus 52.8 ± 4.3 $p<0.05$) (Table 2.3).

2.5.4 Clinical and Physical Measures

No differences in mean A1c were seen for participants who reported consuming ≥ 5 servings of VF and avoiding processed high fat foods. Pairwise comparisons however showed differences in mean A1c between those who included low-GI foods in their diets for 1-2 days and 3-4 days and between 3-4 days and 5-7 days ($p<0.05$) but no uniform pattern was observed (Table 2.4).

2.6.0 Discussion

This study found agreement between self-reported dietary practices using a previously validated tool and usual intakes using the Block FFQ. Those who reported eating ≥ 5 servings of VF and avoiding processed high fat foods as well as included low-GI foods in their diet on most days/week did indeed have higher carbohydrate quality based on GI, and lower mean intakes of saturated fat, trans fat, and added sugars. The results were not as convincing for glycemic control (A1c) among those who reported including low-GI foods in their diet on most days/week.

A major strength of the present study is the use of a new question about weekly GI intake alongside the SDSCA [145]. Data from the Block Screener used in this study [146-149] corresponded well with dietary practices reported in responses to the SDSCA and low-GI questions. The SDSCA [145]is a validated and widely used self-report measure of diabetes self-management behaviour in practice and research settings. However, there is no simple validated tool for capturing GI-based dietary practices, an important component of medical nutrition therapy for people with diabetes [6, 40, 152]. The observed consistency between self-reported inclusion of low-GI foods in the diet and usual dietary intakes suggests that, responses to the question: “Have you followed an eating plan that includes low-GI foods?” can serve as a quick and accurate self-reported proxy measure for low-GI dietary behaviour among people with type-2 diabetes. The approach used here for estimating GI intake was based on a ‘per week’ referent, and we showed those who reported a greater number of days tend to reflect better low-GI dietary practices. By this approach, the time and costs associated with using FFQs for capturing low-GI dietary behaviour can be reduced; which is important for patients, researchers and clinicians. Further research to improve the measurement properties of the low-GI question and other aspects of GI knowledge and practice may be required.

Over one-quarter of individuals reported that they did not include low-GI foods in their eating plans and 16% were unfamiliar with the GI concept. These results are disconcerting given that current nutrition strategies for people with type-2 diabetes recommend low-GI eating [6, 40, 152]. A possible explanation for this observation could be inadequate GI concept knowledge. It has been shown that less than half (38%) of people with type-2 diabetes receive nutrition counseling in Canada [15]. Moreover, GI clinical utility has been debated and facilitation of the GI concept education among registered dietitians (RDs) in Canada is inadequate; with less than 40% including GI concept as part of medical nutrition therapy for diabetes treatment and prevention [18, 19]. Nevertheless, the majority of participants reported following a low-GI diet to some extent and those who did on more days/week also had an overall higher quality diet.

This study is not without limitations. Participants' self-care dietary practices and intake data were collected at baseline prior to the HEALD intervention [74]. As a secondary analysis of cross-sectional data there is no evidence of a temporal relationship between exposure and outcome. Further, the Block Screener used in this study was optimized for obtaining rough estimates of usual intake of fat, sugar, vegetables, and fruit. These estimates are valuable for examining relationships between specific dietary components and other variables when time is constrained or assessment of total diet is not required. However, due to the shorter food list, it may result in underestimated dietary energy and total nutrient intakes. In addition, the Canadian nutrient file was not used in the analysis of these diet data. Lastly, dietary intake estimates are prone to social desirability bias and all tools used in this study may also have been susceptible to recall bias.

2.7.0 Relevance to Practice

Capturing self-care dietary practices using the SDSCA and quantifying dietary intakes with a FFQ can be considered valuable approaches for healthcare providers supporting people with type-2 diabetes. The low-GI item included in this study may serve as a quick self-report measure of low-GI dietary behaviour and possibly serve as a marker of a better overall dietary intake.

Table 2.1: Baseline characteristics of the study population

Characteristic	Study population (N=196)
Age (years)	59.6 ± 8.4
Sex, n (%)	
Male	96 (49.0)
Female	100 (51.0)
Marital status, n (%)	
Married or common law	152 (77.6)
Not married	44 (22.4)
Ethnicity, n (%)	
Caucasian	185 (94.4)
Non-Caucasian	11 (5.6)
Education, n (%)	
High school and less	65 (33.2)
College and higher	131 (66.8)
Employment, n (%)	
Employed	122 (61.6)
Unemployed	76 (38.4)
Smoking status, n (%)	
Non-Smoker	82 (41.8)
Ex-smoker	87 (44.4)
Current smoker	27 (13.8)
Duration of diabetes (years)	5.1 ± 6.3
BMI (kg/m^2)	33.6 ± 6.5
Weight (kg)	96.4 ± 20.7
Waist circumference (cm)	110.8 ± 15.2
Resting heart rate (beats/min)	70.8 ± 10.8
Systolic BP (mmHg)	125.6 ± 16.3
Diastolic BP (mmHg)	75.8 ± 8.6
HbA1c (%)	6.8 ± 1.1
LDL cholesterol (mmol/L)	2.3 ± 0.8
HDL cholesterol (mmol/L)	1.2 ± 0.4
Triglycerides (mmol/L)	1.8 ± 1.0
Total cholesterol (mmol/L)	4.3 ± 0.9

Data are means ± SD

Table 2.2: Summary of Diabetes Self-Care Activities[145] Specific Dietary Practices and Intakes

Self-care dietary practice	**Number of days/week**				
	0-3	4	5	6-7	
Consumed ≥ 5 servings of vegetables and fruit and avoided high fat processed foods	**n=34**	**n=57**	**n=48**	**n=57**	***p*-value**
Calories (kcal)	1444.5 ± 497.3	1238.7 ± 443.9	1306.7 ± 522.2	1220.4 ± 376.6	0.12
Protein (g/d)	63.9 ± 19.7	57.6 ± 24.4	61.9 ± 26.3	59.7 ± 18.1	0.58
Total Fat (g/d)	61.0 ± 24.5	51.1± 20.0	54.0 ± 23.3	46.5 ± 17.7	0.02
Saturated fat (g/d)	20.2 ± 8.7	16.8 ± 7.1	16.6 ± 7.3	14.2 ± 6.1	<0.01
Trans fat (g/d)	3.9 ± 3.4	3.1 ± 2.7	2.6 ± 2.5	1.6 ± 1.8	<0.01
Carbohydrate (g/d)	163.9 ± 62.2	141.1 ± 54.0	147.6 ± 65.2	147.7 ± 51.6	0.34
Total sugar (g/d)	62.2 ± 29.3	55.4 ± 31.1	53.9 ± 33.1	61.9 ± 29.9	0.43
Added sugars (g/d)	30.5 ± 25.2	23.2 ± 22.4	20.6 ± 20.4	16.8 ± 16.2	0.03
Fruit (Cup equivalents)	1.3 ± 1.0	1.4 ± 0.9	1.6 ± 1.0	2.2 ± 0.9	<0.01
Vegetable (Cup equivalents)	1.5 ± 0.9	1.6 ± 0.8	1.9 ± 0.9	2.1 ± 0.9	<0.01
Vegetable and Fruit (Cup equivalents)	2.7 ± 1.4	2.9 ± 1.4	3.4 ± 1.4	4.3 ± 1.4	<0.01
Fibre (g/d)	13.0 ± 6.0	11.9 ± 4.8	13.2 ± 5.4	14.1 ± 4.4	0.13
Glycaemic Index	53.7 ± 3.5	51.8 ± 4.8	52.4 ± 4.8	49.8 ± 4.1	<0.01
Glycaemic Load	80.9 ± 31.9	66.6 ± 25.6	70.3 ± 32.2	66.0 ± 23.0	0.07

Data are means ± SD. Significance set at $p < 0.05$.

Table 2.3: Consumption of Low Glycemic Index Foods and Dietary Intakes

Self-care dietary practice	Number of days/week				
	0	**1-2**	**3-4**	**5-7**	
Followed low-GI eating plan	**n=55**	**n=44**	**n=45**	**n=52**	***p*-value**
Calories (kcal)	1384.7 ± 468.9	1269.9 ± 432.1	1248.8 ± 472.8	1226.5 ± 457.5	0.29
Protein (g/d)	60.6 ± 21.3	58.6 ± 18.7	60.5 ± 27.2	61.5 ± 22.4	0.94
Total Fat (g/d)	58.5 ± 22.9	50.5 ± 18.6	49.9 ± 22.1	48.9 ± 20.8	0.08
Saturated fat (g/d)	18.9 ± 8.2	16.3 ± 6.8	15.7 ± 7.6	15.2 ± 6.3	0.04
Trans fat (g/d)	3.6 ± 3.4	3.0 ± 2.8	2.4 ± 2.0	1.8 ± 1.8	0.01
Carbohydrate (g/d)	158.2 ± 57.3	150.9 ± 59.3	142.9 ± 55.1	141.3 ± 59.3	0.41
Total sugar (g/d)	62.3 ± 32.8	61.4 ± 35.3	54.4 ± 27.3	54.0 ± 27.8	0.38
Added sugars (g/d)	30.6 ± 26.1	24.7 ± 21.9	18.4 ± 16.5	13.6 ± 13.9	<0.01
Fruit (Cup equivalents)	1.5 ± 1.0	1.7 ± 1.2	1.6 ± 1.0	1.7 ± 1.2	0.90
Vegetable (Cup equivalents)	1.6 ± 0.8	1.6 ± 0.8	1.9 ± 1.0	2.0 ± 1.0	0.11
Vegetable and Fruit (Cup equivalents)	3.2 ± 1.4	3.3 ± 1.5	3.5 ± 1.5	3.7 ± 1.6	0.41
Fibre (g/d)	12.9 ± 4.8	12.6 ± 4.9	13.2 ± 5.3	13.4 ± 5.4	0.86
Glycaemic Index	52.8 ± 4.3	52.2 ± 4.5	50.9 ± 5.0	50.7 ± 4.4	0.05
Glycaemic Load	76.2 ± 28.5	71.4 ± 27.2	65.9 ± 26.5	65.0 ± 29.2	0.14

Data are means ± SD. Significance set at $p < 0.05$.

Table 2.4: Dietary Practices and Clinical Outcomes

Dietary practice/Outcomes	Number of days/week				
	0-3	4	5	6-7	
Consumed ≥ 5 servings of vegetables and fruit and avoided high fat processed foods	**n=34**	**n=57**	**n=48**	**n=57**	**p-value**
BMI (kg/m^2)	35.1 ± 7.3	33.8 ± 6.7	33.2 ± 7.0	32.9 ± 5.4	0.45
Systolic BP (mmHg)	122.9 ± 15.8	126.7 ± 16.4	126.4 ± 16.9	125.4 ± 16.2	0.73
Diastolic BP (mmHg)	75.9 ± 7.7	76.9 ± 7.7	76.1 ± 8.9	74.2 ± 9.7	0.42
LDL cholesterol (mmol/L)	2.2 ± 0.6	2.4 ± 0.8	2.4 ± 0.8	2.3 ± 0.7	0.61
HDL cholesterol (mmol/L)	1.1 ± 0.3	1.2 ± 0.4	1.2 ± 0.5	1.3 ± 0.4	0.48
Triglycerides (mmol/L)	1.7 ± 1.0	1.9 ± 1.1	1.8 ± 1.3	1.6 ± 0.8	0.29
Total cholesterol (mmol/L)	4.2 ± 1.0	4.5 ± 0.9	4.4 ± 1.0	4.2 ± 0.9	0.40
HbA1c (%)	6.7 ± 1.1	6.9 ± 1.2	6.8 ± 1.0	6.7 ± 1.0	0.82
Replaced high-GI with low-GI foods	**0** **n=55**	**1-2** **n=44**	**3-4** **n=45**	**5-7** **n=52**	**p-value**
BMI (kg/m^2)	33.9 ± 5.5	34.4 ± 6.9	33.4 ± 6.9	32.9 ± 6.8	0.67
Systolic BP (mmHg)	124.7± 14.0	125.3 ± 19.1	128.5 ± 16.8	124.3 ± 15.7	0.59
Diastolic BP (mmHg)	76.1 ± 8.2	76.4 ± 9.3	77.0 ± 8.6	73.8 ± 8.4	0.28
LDL cholesterol (mmol/L)	2.4 ± 0.7	2.2 ± 0.6	2.4 ± 0.8	2.3 ± 0.9	0.66
HDL cholesterol (mmol/L)	1.1 ± 0.3	1.2 ± 0.4	1.2 ± 0.4	1.2 ± 0.5	0.33
Triglycerides (mmol/L)	1.9 ± 1.2	1.7 ± 1.1	1.7 ± 1.0	1.8 ± 0.9	0.88
Total cholesterol (mmol/L)	4.3 ± 1.0	4.3 ± 0.7	4.4 ± 0.9	4.3 ± 1.1	0.90
HbA1c (%)	6.9 ± 1.0	6.6 ± 1.2	7.1 ± 1.2	6.5 ± 0.8	0.04

Data are means ± SD. Significance set at $p < 0.05$.

CHAPTER 3

Examining sex differences in glycemic index knowledge and intake among individuals with type 2 diabetes

3.1.0 Abstract

Aim: We examined self-reported dietary behaviours and actual food intakes among adult men and women with type 2 diabetes participating in Alberta's Caring for Diabetes (ABCD) Study.

Methods: Participants completed 3-day food records and questions about glycemic index (GI) concept knowledge and dietary behaviours. Daily average GI and glycemic load (GL) were calculated for all carbohydrates consumed. Dietary intake was analyzed using ESHA FoodPro (version 10.13.1). Sex differences in nutrient intakes were explored across categories of GI knowledge and dietary practices.

Results: Participants (N=170) mean (SD) age 65.8 (9.6) years were 46.5% women, 90.6% Caucasian with a mean BMI of 31.3 (7.0) kg/m^2 and diabetes duration of 13.4 (8.6) years. Overall, 60% of men vs. 40% of women consumed carbohydrates in quantities below Acceptable Macronutrient Distribution Ranges (AMDR). About 80% of men vs. 90% of women consumed proteins above AMDR whereas 60% of men vs. 65% of women consumed fats above AMDR. Fibre intake among men was lower than recommended (p<0.01). Men who reported having knowledge of the GI-concept also reported lower GI intake versus men who did not (p=0.03).

Conclusion: Sex differences exist in low-GI diabetes self-care dietary behaviours among adults with type 2 diabetes participating in this study. Gender-sensitive approaches for enhancing diabetes self-care low-GI dietary behaviour should be explored.

Key Words: Glycemic Index, Type 2 Diabetes, Sex differences

Note: A version of this chapter was previously published as Avedzi H, Mathe N, Storey K, Johnson JA, Johnson ST. Examining Sex Differences in Glycaemic Index Knowledge and Intake Among Individuals with Type 2 Diabetes. Primary Care Diabetes 2018;12(1):71-79.

3.2.0 Introduction

Effective strategies for achieving metabolic control continue to be sought in the wake of the burgeoning diabetes epidemic and associated human and economic costs globally. Healthy eating plays a pivotal role in diabetes self-management for preventing and managing long-term complications. Dietary advice and education to include low glycemic index (GI) foods in daily meal planning as a viable self-care dietary strategy for improving glycemic control and health outcomes among individuals with diabetes therefore need evaluation [39, 103, 104].

The GI concept emphasizes carbohydrate quality as part of an overall healthy eating behaviour and is recommended by the Canadian Diabetes Association Clinical Practice Guidelines for guiding food selection among people living with diabetes [11, 39, 101, 112]. Briefly, the GI concept ranks dietary carbohydrates based on their immediate impact on postprandial glycemia (glycemic response). On a scale of 0 to 100, foods that cause the most rapid rise in blood sugar within two hours receive higher values and pure glucose, with a GI of 100, serves as the reference. For practical application of the GI concept, glycemic load (GL) has been developed to measure the degree of glycemic response and insulin demand produced by a specific amount of a specific food [10]. GL therefore reflects quality and quantity of dietary carbohydrate foods. Adoption of the low-GI dietary pattern as part of an overall healthy eating lifestyle has been shown to significantly improve glycemic control, cardiovascular risk factors (e.g. total cholesterol, HDL), beta cell function and decreased need for anti-hyperglycemic agents among individuals with diabetes [10, 39, 40, 103-111].

Food choices and adherence to nutritional recommendations differ significantly between men and women [153-155]. Similarly, sex differences in diabetes self-management, known to influence essential daily living activities such as coping with dietary self-care, physical activity, and blood glucose monitoring, also exist [156-160]. For example, women show greater adaptability to diabetes and are generally more likely to seek knowledge for diabetes management, use socially interactive resources like education classes and support groups [158], be concerned about heart disease, and be non-smokers [157]. Compared to men, women tend to have better dietary practices including consuming significantly more legumes, vegetables, fruits, eggs, milk, and vegetable oils [156] and avoid high fats or high calorie foods [157]. To date however, very little evidence exists regarding differences in adherence to low-GI dietary behaviour between men and women with type 2 diabetes. Consequently, the adequacy of nutrition knowledge and influence of sex differences on the awareness and application of the GI concept in daily dietary self-care practices of people with T2D remains unknown. Therefore, we examined the following questions: 1) Does GI concept knowledge among people with type 2 diabetes in Alberta, Canada translate into corresponding dietary behaviour and intakes? 2) Are low-GI choices and intakes among adults with diabetes associated with their current GI-related stage of change? 3) Are there sex differences in GI-knowledge, GI-related stage of change, and dietary behaviour? We hypothesized that those individuals who reported having GI concept knowledge would report dietary behaviour and intakes consistent with their knowledge and stage of GI behaviour change. We also hypothesized males would have less GI concept knowledge and higher GI intake.

3.3.0 Methods

3.3.1 Study Population and Setting

Adults (≤18 years) with type 2 diabetes, enrolled in the ABCD Cohort study [161], provided data for this study. All ABCD cohort participants completing year three assessment (N=1942) received an invitation to participate and from these, 1313 (68%) responded to the survey invitation, 780 declined and 533 accepted. From these, a sample of roughly 50% (n=248) was drawn, using quota sampling to reflect distribution across five provincial health zones (North, Central, Edmonton, Calgary and South) in an effort to reflect diabetes prevalence across these regions (i.e., greater prevalence in Urban locations). The 248 participants were mailed a study package that included postage-paid return envelope. The Health Research Ethics Board at the University of Alberta granted study approval and all participants provided written informed consent.

3.3.2 Socio-Demographic Characteristics

A paper-based questionnaire was used to determine age, marital status, ethnicity, education, income, occupation, smoking status, and time since diabetes diagnosis. Participants were also asked to report their current height and weight, from which a body mass index (BMI) was calculated in kg/m2.

3.3.3 Dietary Assessment

All participants completed a 3-day food record (i.e. two week days and one weekend day) and were asked to provide in as much detail as possible, descriptions of foods and beverages consumed [162]. Participants had access to an online video, which was developed to give further instructions on how to fill in the 3-day food records [163]. Coloured photographs were included in the 3-day food record to assist with estimating and recording appropriate portion sizes of foods and beverages consumed. Photographs included common household items such as spoons, a drinking glass and a measuring jug. Pictures showing sample portions sizes of foods measured against items including a finger, palm of a hand and a hockey puck were included and participants were encouraged to choose the photograph that best represented their portion size or indicate if they consumed more or less [132]. Dietary intake data were entered and analyzed using the Food Processor Diet Analysis and Fitness Software version 10.13.1 (ESHA Research, Salem, USA) to yield estimates of mean daily food consumption and nutrient intakes based on the Canadian nutrient file [164].

3.3.4 Glycemic Index and Glycemic Load Estimation

All carbohydrate-containing foods identified from the 3-day food record were assigned GI values corresponding to the best geographic and botanical matches in published International Table of Glycemic Index and Glycemic Load Values [151, 165] or the updated University of Sydney online database (www.glycemicindex.com) by the same investigators. GI values were averaged for foods having more than one GI value from very similar matches. As a limitation, the International Table and the University of Sydney online databases do not provide an exhaustive entry of glycemic data for all foods. Thus, in instances where foods could not be matched directly to those in the International Tables/online database, they were calculated from Estimated Glycemic Load [166] or matched to listed foods with similar characteristics (ingredients, composition, and physical properties) based on all information available to the nutritionist (HA) and from his subjective experience and knowledge of foods [113, 167, 168]. As recommended [167-169], daily average GI and GL were calculated as follows:

$$\text{Total Dietary GL} = \left(\sum_{X=1}^{n} GI_x * CHO_x\right)/100$$

$$\text{Total Dietary GI} = \left(\sum_{x=1}^{n} GI_x * CHO_x\right) / \sum_{x=1}^{n} CHO_x$$

(where GIx is GI for food x, and n the number of foods eaten per day; CHOx represents available carbohydrate in gram weight of food x; and ΣCHOx is the average of total available carbohydrate eaten over the 3 days. FoodPro software provided CHO content of foods necessary for GI and GL calculations and CHO values are based on available carbohydrates (total CHO - dietary fibre).

3.3.5 Self-Care Dietary Behaviour, Glycemic Index Knowledge, and Stages of Change

Participants answered general questions regarding their dietary self-care practices using Canada's Food Guide [86] as the reference for healthy eating as well as knowledge and inclusion of low-GI foods in their diets. Participants' GI concept knowledge was assessed using a question adapted from a previous measure [16] "Do you know what the Glycemic Index is?" with response options "Yes" or "No". Participants also answered questions regarding their readiness to consume low-GI foods. Briefly, to assess readiness, the Trans-Theoretical Model was used to describe what stage of readiness (i.e., pre-contemplation, contemplation, preparation, action and maintenance) participants were occupying in relation to low-glycemic index food consumption [60, 61]. For this study, stage occupation for low-GI food choices were assessed through two questions adapted from a previous measure [170]. Specifically, one question asked participants "Do you consistently avoid eating high Glycemic Index foods?" and the other "Do you normally choose low Glycemic Index foods?" Five response options for each question were: 1) No, and I do not plan to do so in the next 6 months = pre-contemplation; 2) No, but I was thinking about doing so in the next 6 months = contemplation; 3) No, but I planned to in the next 30 days = preparation; 4) Yes, but I have only begun in the past 6 months = action; 6) Yes, and I have been doing so for longer than 6 months = maintenance.

The two low-GI stages of change questions were used and structured to estimate interrelatedness. Spearman's correlation of the two items showed a strong positive monotonic relationship (rs =0.99), indicating that choosing low-GI foods is associated with avoiding high GI foods and suggests unidemensionality. These were therefore merged into a single item: "Do you normally choose low-GI instead of high-GI foods?" with a Cronbach's Alpha ($\alpha = 0.99$) showing reliability of the new summative rating scale. Furthermore, participants' stage occupation for low-GI choices were categorised into three groups: Pre-Action (pre-contemplation, contemplation, or preparation), Action/Maintenance and No response. Fisher's exact (chi-square) test was conducted between categories of GI knowledge (yes versus no) and stage occupation for low-GI choices (Pre-Action, Action/Maintenance, and No response) to confirm consistency in responses by correctly identifying stage occupation for low-GI choices based on GI concept knowledge. Test results showed a strong relationship ($p<0.001$) between GI knowledge and stage readiness for low-GI choices.

3.4.0 Statistical Analyses

Descriptive analyses were completed for socio-demographic characteristics. Participants with extreme mean energy intakes <500 or >5000 kcals (n=6) were removed from the analysis using Goldberg cut-offs [171, 172]. Energy and nutrient intakes were compared with Dietary Reference Intakes (DRIs) and mean daily GI and GL were compared with low to medium cut offs [10, 115]. Standardized effect sizes (Cohen's d) were calculated for comparing the magnitude of the differences in dietary intakes between men and women [173]. Dietary intakes, GI and GL of men and women were compared based on GI knowledge using two independent samples t-test. One-way analysis of variance (ANOVA) was used in comparing stage occupation for low-GI choices (Pre-Action, Action/Maintenance, and No response) and Tukey's post hoc pairwise comparisons were used to further explore statistically significant differences observed during the omnibus test.

All statistical analyses were performed using STATA (version 12.1, StataCorp, College Station, Texas, USA) and p-values <0.05 were considered significant.

3.5.0 Results

3.5.1 Socio-Demographic Characteristics

Out of 248 eligible participants sampled for the ABCD Cohort dietary and physical activity sub-study, 186 completed socio-demographic surveys and provided 3-day food records (75% response rate). Participants with incomplete surveys or food records (n=10) and extreme energy intakes (n=6) were eliminated leaving 170 for analysis. Participants mean (SD) age 65.8 (9.6) years were 47% women, 91% Caucasian with mean BMI 31.3 (7.0) kg/m2, with diabetes duration of 13.4 (8.6) years Table 3.1).

3.5.2 Dietary Assessment

Participants' (n=170) mean (SD) energy was 2089.9 (662.9) kcals/day and was different between men (2218.6 ± 635.4) and women (1941.6 ± 666.8) (p<0.01). Energy intake among men did not differ from recommended for the average Canadian man (51-70 y). Among women, energy intake was higher than the average Canadian female (51-70 y) of similar physical activity level (Table 2). About 60% of men had carbohydrate intakes below the Acceptable Micronutrient Distribution Ranges (AMDR) while 80% and 60% had protein and total fat intakes above the AMDR respectively. Forty per cent of women consumed carbohydrates below the AMDR while 90% and 65% exceeded the AMDR for protein and total fat intakes respectively. Fibre intake among men was also significantly lower than recommended for individuals with type 2 diabetes [39] (Table 3.2).

3.5.3 Glycemic Index and Glycemic Load

Overall mean (SD) daily GI and GL were 50.1 (6.3) and 111.4 (46.8) respectively. Participants' mean daily GI was significantly below the low-GI cut-off (55) recommended for healthy living [10, 174]. Mean daily GL for both men and women was within low to moderate cut-off (>80 to <120) [174] (Table 3.2).

3.5.4 Self-Care Dietary Behaviour, Glycemic Index Knowledge, and Stages of Change

For the overall sample, dietary intakes, GI, and GL did not differ based on GI concept knowledge (Table 3.3). Fifty six percent of men and 63% of women reported knowing about the GI concept. For men, those who indicated "Yes" to GI concept knowledge also reported lower mean daily GI intake compared with those who responded "No" (51.6 versus 49.5; p=0.03; effect size 0.5). Among women, dietary intakes, GI and GL did not differ based on GI concept knowledge (Table 3.3).

Dietary intakes, GI, and GL did not differ based on stage occupation for low-GI dietary behaviour in the overall sample. However, 19% and 36% men were categorized as being in "Pre-Action", "Action/Maintenance" based on their stage occupation for low-GI dietary behaviour while 45% did not respond to the stage readiness questions (Table 3.4). A Fisher's exact (chi-square) test comparing men's categories based on GI concept knowledge and stage occupation for low-GI dietary behaviour showed that, 95% of men who reported no knowledge of GI concept also gave "No response" to the stages of change for low-GI food choices (p<0.001). Similarly, 94.1% (16 out of 17) and 97% (32 out of 33) men who responded "Yes" to the GI concept knowledge also self-identified as occupying the "Pre-Action" and "Action/Maintenance" stages respectively (p<0.001). GI intake was significantly different across categories of stage occupation for low-GI dietary behaviour among men (p=0.02) (Table 3.4). Post hoc pairwise comparisons showed that, compared with "No Response", men in "Pre-Action" and "Action/Maintenance" had significantly lower GI intake (p=0.02 for both).

Twenty-four percent and 38.0% of women were categorized as "Pre-Action" and "Action/Maintenance" based on stage occupation for low-GI dietary behaviour while 38.0% did not respond to the stage readiness questions (Table 3.4). Fisher's exact test comparisons of categories based on GI concept knowledge and stage occupation for low-GI dietary behaviour showed that, 93% of women who reported no knowledge of GI also gave "No response" to the stages of change for low-GI food choices (p<0.001). Similarly, 100% and 93% of women who responded "Yes" to the GI concept knowledge also self-identified as occupying the "Pre-Action" and "Action/Maintenance" stages respectively (p<0.001). However, GI intake was not significantly different across categories of stage occupation for low-GI dietary behaviour among women (Table 3.4).

3.6.0 Discussion

This study examined associations between dietary behaviours, GI concept knowledge, and actual intakes among adults with type 2 diabetes [161] . Only one third of men and about half of the women who participated in this study consumed dietary carbohydrates in quantities within the AMDR for their age and gender groups [175, 176]. Most participants met energy needs through consumption of proteins and fats in amounts exceeding recommendations. Fibre intakes among men were lower than recommended for individuals with diabetes. AMDRs are ranges of macronutrient (carbohydrates, fats, and proteins) intakes that provide adequate essential nutrients and are associated with reduced risk of chronic diseases [175]. Compared with energy and nutrient intakes of other Canadian adults, a higher proportion of men and women in this study consumed proteins and fats in excess of AMDR [177]. Increasing fat intakes to ≥35% has been shown to impact metabolic profiles and markers of low-grade inflammation, including increased LDL-cholesterol, triglycerides, HbA1c and C-reactive proteins significantly among people with T2D [178]. Carbohydrate and fibre intakes ≥60% and ≥15g/1000 kcal respectively have however been associated with significantly better lipid profiles and lower HbA1c and C-reactive proteins [178].

Men and women differed on GI intake in this study. Men who indicated having GI concept knowledge also reported a lower GI intake compared with those who did not. Compared with "No Response", men occupying "Pre-Action" and "Action/Maintenance" stage for low-GI food choices reported lower mean daily GI. Men in Action/Maintenance stage also reported lower total cholesterol intakes consistent with previous findings associating consumption of low-GI foods with improvements in total cholesterol [104], high-density lipoproteins, and reduced triacylglycerol concentrations [179]. We also observed a strong relationship between GI concept knowledge and stage occupation for low-GI choices for both sexes. Majority (>90%) of those with GI knowledge occupied a stage and those without knowledge did not indicate their stages of readiness. These results reflect consistency in participants' GI knowledge and dietary self-care behaviour, giving considerable indication that GI knowledge is very likely an important factor in determining readiness for low-GI dietary choices among men. Various studies examining sex differences in diabetes self-management have generally reported better dietary self-care behaviour among women [156-160]. Women consumed more legumes (which tend to have low-GI), vegetables, fruits, eggs, milk [156], and avoided high fats/calorie foods [157] than men. To the best of our knowledge however, the present study is the first to examine differences in the awareness and application of low-GI concept in daily dietary self-care among men and women with T2D.

The glycemic index concept has been associated with improved carbohydrate and overall diet quality, self-care practices, and metabolic outcomes among adults living with diabetes [109, 116]. However, replacing high with low-GI foods without adequate knowledge of GI concept as part of overall healthy eating practices can increase fat intakes [109, 179], as some foods (e.g. ice cream) which have high fat and protein contents tend to have lower GI values [10, 169]. While participants reported low mean daily GI intakes in this study, they also consumed proteins and fats in quantities exceeding the AMDR. Burani and Longo [180] noted that, some participants in a previous study haphazardly followed a low-GI diet until their GI knowledge improved through GI concept targeted education. Thus, a more proactive GI concept-based nutrition education targeting overall diet quality may be effective in preventing consumption of fats and protein in quantities exceeding the AMDR.

Comparisons of demographic characteristics of men, based on stage occupation for low-GI behaviour, showed that those in “Action/Maintenance” had relatively higher mean age and diabetes duration. These could be indications that these men gleaned enough GI concept information over an extended period of time to influence their GI dietary behaviour. A possible explanation could be the inadequacy of low-GI targeted nutrition education for people with diabetes in Canada. Clinical utility and application of the GI concept in the nutritional management of diabetes have been debated among dietitians in Canada and less than 40% include the GI concept in nutrition counseling [18, 19]. Besides, many diabetes patients do not receive routine nutrition therapy for managing their condition [15]. Investigating correlates of low-GI dietary behaviour and enhancing knowledge, skill and self-efficacy for consuming low-GI foods using approaches similar to the POWERPLAY intervention [181] may therefore be valuable for improving healthy dietary self-care among men with type 2 diabetes.

A major strength of this study is the use of 3-day food records to collect dietary intake data and the use of the Canadian Nutrient File for generating nutrient intakes. Use of the 3-day food records reduces challenges with recall bias which is common with dietary assessment methods such as the commonly used 24-Hour recall and is also more likely to capture greater coverage of usual dietary intakes [132]. Data from the 3-day food records corresponded well with self-reported practices, showing sex differences in diabetes dietary self-care behaviour. Findings from this study should however be interpreted in the light of the following limitations. Self-reported measures are known to be prone to social desirability bias. Self-reported diabetes dietary self-care practices and intake estimates should therefore be interpreted with caution. Also, as a cross-sectional study, causal inference cannot be drawn between variables reported.
Absence of DRIs for GI/GL has been cited as a limiting factor affecting clinical utility, interpretation of GI research, and application among people with diabetes. While a dose response relationship between GL and T2D has been reported [182], others have raised the need to recognize the numerical difference between low-GI foods and low-GI diet [183, 184]. Concerns regarding the numerical difference between low-GI foods and diet were born out of available evidence suggesting that a diet averaging a GI of 55 or less may not necessarily be representative of a low-GI eating pattern. Findings from clinical studies comparing high and low-GI eating regimes have suggested that, to be considered low-GI, a diet must average a GI value around 45 [102, 185, 186]. Similar finding have been reported in population-based studies and were

associated with reduced risk for chronic disease thus presenting valid concerns for cutoffs to define low or high GI/GL diets instead of using cutoff for foods [184]. In the absence of established DRI for low-GI/GL diets and given that other studies have reported favorable outcomes by encouraging substitution of healthy low-GI for high GI foods [109, 184], we maintained the International Carbohydrate Quality Consortium (ICQC) low, medium and high GI/GL cut-offs in our analysis [10]. Besides, this approach was adopted because the current study was set up to examine sex differences in GI knowledge and intake among individuals who received messages encouraging them to substitute healthy low-GI for high GI foods within food groups (i.e. this for that) [6, 184].

Definition and validity of GL have also generated some controversies since inception, thereby limiting its use [184, 187]. Definition of GL, especially available carbohydrate, was addressed in this study by adopting the ICQC definition [10]. Regarding GL validity, it has been shown that focusing on attaining an overall low GL diet as a strategy to prevent spikes in postprandial glycemia and improve health outcomes can result in unhealthy food choices and ultimately, low diet quality. This can occur when consumers eat less carbohydrate and try to make up for energy needs with fats and proteins in excess of guideline recommendations because they contain little or no carbohydrate [184]. We therefore focused on GI in our study because it has been shown that substituting high GI foods with healthy low-GI options within acceptable carbohydrate guideline (AMDR) recommendations is more likely to produce a healthy low-GI diet overall [184, 188].

3.7.0 Conclusion and Recommendations

Sex differences exist in low-GI diabetes self-care dietary behaviours among men and women with T2D. Given that low-GI is a marker of carbohydrate and overall diet quality, simply improving GI-concept knowledge may be a valuable first step for improving a lower glycemic index intake. Furthering our understanding of how and why men and women behave differently can serve to inform development of gender-sensitive approaches for enhancing diabetes self-care dietary practices among people living with T2D.

Table 3.1: Demographic Characteristics

Characteristic	All (Total N=170)	Men (N=91)	Women (N=79)
	N or mean (% or SD)	*N or mean (% or SD)*	*N or mean (% or SD)*
Age (years)	65.8 (9.6)	67.0 (9.6)	64.5 (9.5)
Married (%)			
Married or common law	135 (79.4)	81 (89.0)	54 (68.4)
Not married	29 (17.1)	7 (7.7)	22 (27.9)
Separated, but not divorced	6 (3.5)	3 (3.3)	3 (3.8)
Education			
High school and less	84 (49.4)	44 (48.4)	40 (50.6)
College and higher	86 (50.6)	47 (51.7)	39 (49.4)
Employed (%)			
Employed (part- full- time or self-employed)	63 (37.1)	35 (38.5)	28 (35.4)
Unemployed	2 (1.2)	1 (1.1)	1 (1.3)
Other (retired, homemaker, disabled, and other)	105 (61.8)	55 (60.4)	42 (53.2)
Ethnicity			
Caucasian	154 (90.6)	80 (87.9)	74 (93.7)
Non-Caucasian	14 (8.2)	9 (9.9)	3 (3.8)
Missing	2 (1.2)	2 (2.2)	2 (2.5)
Income (Canadian dollars)			
<$40,000	38 (22.4)	14 (15.4)	24 (30.4)
$40,000-$79,999	57 (33.5)	32 (35.2)	25 (31.7)
>= $80,000	48 (28.2)	32 (35.2)	16 (20.3)
Don't know/ refused	27 (15.9)	13 (14.3)	14 (17.7)
Smoking status			
Non-Smoker	73 (42.9)	28 (30.8)	45 (57.0)
Current smoker	8 (4.7)	4 (4.4)	4 (5.1)
Occasional smoker	1 (0.6)	0 (0.0)	1 (1.3)
Ex smoker	84 (49.4)	57 (62.6)	27 (34.2)
No response	4 (2.4)	2 (2.2)	2 (2.5)
Diabetes duration (years)	13.4 (8.6)	14.0 (9.7)	12.7 (7.0)
Physical measures			
BMI (kg/m^2)	31.3 (7.0)	30.7 (6.7)	31.9 (7.2)
Weight (kg)	89.3 (19.6)	94.4 (19.7)	83.3 (18.0)
Mean Glycemic Index	50.1 (6.3)	50.4 (5.1)	49.6 (6.3)
Mean Glycemic Load	111.4 (46.8)	119.6 (52.0)	102.0 (38.3)

Table 3.2: Participants' Self-Reported Intakes Relative to Current Dietary Reference Intakes

Dietary intakes	Men (N=91)				Women (N=79)			
	Actual Intakes	DRI	Effect size	p-value	Actual Intake	DRI	Effect size	p-value
Calories (kcal)	2218.6 ± 635.4	2150.0 Ψ	0.1	0.15	1941.6 ± 666.8	1650.0Ψ	0.4	<0.01
Fibre (g/d)	25.8 ± 10.8	38.0 Ŧ	-1.1	<0.01	23.1 ± 10.4	25.0 Ŧ	-0.2	0.05
Sugars (g/d)	98.0 ± 57.4	53.8 Φ	0.8	<0.01	86.5 ± 45.2	41.3 Φ	1.0	<0.01
Saturated fat (g/d)	27.2 ± 11.2	- †	-	-	27.2 ± 15.2	- †	-	-
Trans fat (g/d)	0.9 ± 0.8	- †	-	-	1.0 ± 1.1	- †	-	-
Cholesterol (mg/d)	330.1 ± 177.3	- †	-	-	294.5 ± 151.0	- †	-	-
Glycemic Index	50.4 ± 5.1	55 §	-0.9	<0.01	49.6 ± 7.5	55 §	-0.7	<0.01
Glycemic Load	119.6 ± 52.0	80 §	0.8	<0.01	102.0 ± 38.3	80 §	0.6	<0.01

Macronutrients	% Below AMDR	% Within AMDR	% Above AMDR	DRI (AMDR)	% Below AMDR	% Within AMDR	% Above AMDR	DRI (AMDR)
Carbohydrates	59.3	34.1	6.6	45 - 65%	36.7	48.1	15.2	45 - 65%
Protein	0.0	23.1	76.9	10 - 30%	0.0	10.1	89.9	10 - 30%
Total Fat	9.9	31.9	58.2	25 - 35%	5.0	30.4	64.6	25 - 35%

Data are means ± SD. Significance set at $p < 0.05$ (t-test for H_O: Difference=0).

Ψ DRI based on Canada's Food Guide (Health Canada) Estimated Energy Requirements [176] using participants' mean age and physical activity level.
Ŧ Health Canada Dietary Reference Intakes Tables [175] and DRI based on Canadian Diabetes Association Nutrition Therapy Clinical Practice Guidelines [39]
Φ Calculated from Health Canada DRI Tables and CDA Nutrition Therapy Clinical Practice Guidelines using participants' mean demographic characteristics.
† No Upper limit available but individuals are advised to consume "As low as possible while consuming a nutritionally adequate diet" from Ŧ.
§ Based on published recommendations by Glycemic Index experts' Recommendation for optimal health outcomes.
AMDR (Acceptable Micronutrient Distribution Ranges) = *% of total energy intake*

Table 3.3: Glycemic Index Knowledge and Dietary Intakes among Men and Women

Dietary intakes	Men (n=91)				Women (n=79)			
	No (n=40)	*Yes (n=51)*	*Effect size*	*p-value*	*No (n=29)*	*Yes (n=50)*	*Effect size*	*p-value*
Calories (kcal)	2171.0 ± 473.0	2255.9 ± 740.9	-0.2	0.52	1977.7 ± 819.2	1920.7 ± 568.4	0.1	0.72
Carbohydrate (g/d)	258.6 ± 80.9	273.2 ± 125.1	-0.2	0.52	238.7 ± 79.5	226.2 ± 84.3	0.2	0.52
Fibre (g/d)	25.1 ± 8.7	26.4 ± 12.2	-0.1	0.57	21.4 ± 7.4	24.0 ± 11.8	-0.4	0.29
Sugars (g/d)	92.3 ± 40.3	102.4 ± 67.9	0.3	0.41	96.8 ± 49.4	80.5 ± 41.9	0.3	0.12
Protein (g/d)	95.2 ± 25.6	91.6 ± 32.6	0.1	0.57	75.7 ± 32.7	81.5 ± 25.1	-0.2	0.38
Total Fat (g/d)	85.1 ± 26.0	91.5 ± 38.1	-0.2	0.37	81.1 ± 55.1	80.9 ± 29.5	0.004	0.98
Saturated fat (g/d)	27.0 ± 9.4	27.3 ± 12.6	-0.03	0.90	25.9 ± 19.0	28.0 ± 12.6	-0.1	0.54
Trans fat (g/d)	0.8 ± 0.7	1.0 ± 0.8	-0.1	0.44	1.1 ± 1.6	0.9 ± 0.8	0.1	0.42
Cholesterol (mg/d)	357.8 ± 191.5	308.3 ± 163.8	0.3	0.19	294.4 ± 193.6	294.6 ± 121.9	-0.001	0.10
Glycemic Index	51.6 ± 4.3	49.5 ± 5.1	0.5	0.03	50.1 ± 7.6	49.4 ± 7.5	0.1	0.68
Glycemic Load	121.2 ± 39.2	118.3 ± 60.5	0.1	0.79	105.2.0 ± 37.3	100.1 ± 39.1	0.1	0.57

Data are means ± SD. Significance set at $p < 0.05$ (for ANOVA comparing yes/no).

Table 3.4: Stages of Change Regarding Choice of Low-GI Foods and Dietary Intakes

Dietary intakes	Men (n=91)				Women (n=79)			
	Pre-Action (n=17)	*Action/ Maintenance (n=33)*	*No Response (n=41)*	*p-value*	*Pre-Action (n=19)*	*Action/ Maintenance (n=30)*	*No Response (n=30)*	*p-value*
Calories (kcal)	2165.9 ± 553.5	2293.0 ± 832.8	2180.6 ± 473.0	0.70	2003.3 ± 685.5	1850.9 ± 482.1	1993.3 ± 811.2	0.64
Carbohydrate (g/d)	237.2 ± 106.1	290.5 ± 132.9	260.0 ± 80.9	0.22	250.0 ± 100.8	210.9 ± 69.1	238.4 ± 80.1	0.22
Fibre (g/d)	24.0 ± 11.4	26.9 ± 11.1	25.7 ± 10.4	0.67	21.2 ± 5.3	25.4 ± 14.4	21.9 ± 7.6	0.28
Sugars (g/d)	96.2 ± 58.9	107.4 ± 72.8	91.2 ± 40.8	0.48	87.8 ± 54.0	74.3 ± 32.7	97.9 ± 48.2	0.13
Protein (g/d)	98.9 ± 28.5	88.9 ± 35.4	94.3 ± 24.7	0.50	79.8 ± 29.4	79.9 ± 21.9	78.5 ± 33.2	0.98
Total Fat (g/d)	101.2 ± 44.0	86.4 ± 34.5	85.3 ± 26.3	0.23	77.9 ± 30.9	81.7 ± 29.4	82.1 ± 54.2	0.94
Saturated fat (g/d)	30.3 ± 12.3	25.3 ± 12.2	27.4 ± 9.9	0.33	27.6 ± 10.7	27.5 ± 14.0	26.8 ± 18.8	0.98
Trans fat (g/d)	1.1 ± 0.7	0.9 ± 0.8	0.9 ± 0.7	0.58	0.9 ± 0.6	0.9 ± 0.9	1.1 ± 1.5	0.75
Cholesterol (mg/d)	368.5 ± 186.6	268 ± 132.4	364.1 ± 194.3	0.04	277.0 ±137.4	291.3 ± 104.1	308.8 ± 198.8	0.77
Glycemic Index	48.6 ± 5.8	49.4 ± 5.2	52.0 ± 4.2	0.02	50.1 ± 6.8	49.3 ± 8.2	49.6 ± 7.5	0.94
Glycemic Load	103.6 ± 58.8	123.2 ± 62.0	123.2 ± 38.5	0.38	112.8 ± 51.4	93.2 ± 26.9	103.9 ± 37.8	0.21

Data are means ± SD. Significance set at p < 0.05 (for ANOVA comparing pre-action, action/maintenance and no response).

CHAPTER 4

Effectiveness of a web-based glycemic index-targeted nutrition education program on dietary intakes among adults with type 2 diabetes mellitus

4.1.0 Abstract

Background: Rigorous evidence is needed to support uptake of Diabetes Canada's evidence-based recommendations to include low glycemic index (GI) foods in daily meal planning as an effective dietary self-care strategy for people with type 2 diabetes (T2D).

Objective: To evaluate the effectiveness of a 12-week lifestyle intervention with web-based GI-targeted nutrition education on dietary intake and GI-related knowledge among adults with T2D.

Methods: Participants were randomized to a control group (n=34) that received standard printed copies of Canada's Food Guide and Diabetes Canada's GI resources or an intervention group (n=33) that received those same materials, plus an online platform with six self-directed learning modules and supplementary print material. Each module consisted of a customized video, links to reliable websites, chat rooms, and quizzes. Evidence-based GI concept information included GI values of foods and advice for low-GI shopping, recipes, and cooking tips by a Registered Dietitian. Preferred supports through email, text messaging, phone calls, or postal mail to reinforce participants' learning were also made available. The primary outcome, average daily dietary GI intake, was assessed using 3-day food records. Additional measures including GI knowledge and self-efficacy, glycated hemoglobin A1c, lipids, systolic blood pressure, body mass index, waist circumference, and computer proficiency, were assessed at baseline and at three months post-intervention.

Results: Participants (N=67) were 64% men; mean (standard deviation [SD]) age 69.5 (9.3) years, with mean diabetes duration of 19.0 (13.7) years, BMI 30.1 (5.7) kg/m^2, and A1c 7.1

(1.2)% at baseline. At baseline, mean daily GI was similar between intervention 48.60 (7.79) and control 49.06 (7.94). Mean daily GI intake decreased in the intervention group by 2.79 (7.77) compared to a 0.76 (6.48) increase in the control group (adjusted mean difference [95% CI]; -3.77 [-6.95, -0.58]). Mean [95% CI] GI knowledge 2.14 [0.59, 3.69], understanding of GI concept 1.65 [0.85, 2.44] and self-efficacy for identifying and consuming low-GI foods 1.29 [0.51, 2.07] increased among the intervention group ($p<0.01$) compared with the control group.
Conclusion: A web-based education program can improve the quality of carbohydrate consumption among adults with T2D and this behaviour change may have been mediated through increases in knowledge and self-efficacy. Researchers and practitioners should consider web-based delivery as an affective alternative when working with this patient population.

4.2.0 Introduction

Questions regarding what to eat for optimal health constitute a common challenge for people living with and without diabetes. Current dietary approaches to diabetes prevention and management emphasize overall diet quality versus quantity and dietary patterns over single nutrients as essential features of healthy eating [40, 77, 189]. Evidence-informed nutrition guidelines for diabetes self-management are thus shifting towards dietary patterns-based recommendations that are cognizant of ethno-cultural and lifestyle preferences and promote consumption of a variety of healthy foods [2, 4].

Dietary strategies, including the Mediterranean, DASH, vegetarian, and the low glycemic index (GI) concept, have been widely studied and shown to significantly improve overall diet quality, with useful effects for glycemic control and prevention of cardiometabolic complications in people with diabetes [2, 40]. Yet, achieving overall diet quality depends largely on macronutrient quality, particularly fats and carbohydrates [40]. Dietary carbohydrates have the greatest, direct influence on postprandial blood glucose concentration and available evidence suggests that carbohydrate quality (type) may have a greater effect on health outcomes than total amount for the general population [190]. This highlights the unique, pivotal role of the glycemic index (GI) concept as an empirical measure of carbohydrate quality in diabetes prevention and management [2, 40, 123, 190].

Briefly, the GI ranks dietary carbohydrates based on their immediate impact on postprandial glycemia (glycemic response). On a scale of 0–100, foods that cause the most rapid rise in blood sugar within two hours receive higher values and pure glucose (GI: 100) or white bread (GI: 70) serve as the reference [10]. As a unique property of a given food, the GI offers a logical and useful physiological basis for evaluating and classifying carbohydrate-rich foods. Substituting healthy low-GI choices, which elicit a lower glycemic response, for high-GI options within the same food group therefore has benefits for short-term metabolic control and long-term optimal health outcomes [2, 10, 11].

Notwithstanding the body of evidence suggesting potential benefits of GI [2, 75, 101, 103-106, 109, 110, 113-115, 120, 123, 179, 180, 185], its clinical usefulness has been fiercely debated and translation to people with diabetes hindered [12, 13]. In Canada where approximately 10% of the population lives with diabetes, less than 40% of people with diabetes receive regular nutrition therapy [15]. Besides inadequate nutrition care, less than 40% of dietitians who provide nutrition care do actually incorporate the GI concept in patient education; citing inadequate knowledge, teaching tools, and GI concept complexity as reasons [18, 19]. Furthermore, lack of GI knowledge, sex differences in making low-GI choices [16, 17], and GI educational needs [14] have been reported among people with diabetes. Given available GI-related resources, guideline recommendations [2], and promising alternative approaches for engaging, educating, and empowering individuals with chronic diseases such as diabetes using information technologies [20, 21], an intervention was developed to evaluate the effectiveness of an enhanced GI-targeted nutrition education on dietary behaviour and GI intakes among adults with T2D living in Edmonton, Alberta [191].

We therefore designed this study to examine the following questions: 1.) Would adults with T2D who receive GI-targeted nutrition education improve their low-GI foods intake? 2.) Would knowledge and self-efficacy to include low-GI foods in daily meal planning improve among those receiving GI-targeted education? We hypothesized that adults with T2D who receive GI-targeted nutrition education will increase uptake of low-GI eating behaviour in their daily meal planning compared to those receiving usual care.

4.3.0 Methods

4.3.1 Study population and setting

The Healthy Eating and Active Living Glycemic Index (HEALD-GI) trial (ClinicalTrials.gov Identifier: NCT03037099), designed to evaluate the effectiveness of a 12-week GI-targeted nutrition education program among adults with T2D in Edmonton, Alberta, has been described elsewhere [191] and included in the Appendix of this thesis. Briefly, all Alberta's Caring for Diabetes (ABCD) Cohort [161] participants living in Edmonton, Alberta, Canada (N=485) were mailed an invitation to participate in the HEALD-GI study. A total of 84 (17%) individuals responded with phone calls and were screened with 32 deemed eligible to participate. Follow up recruitment calls were placed to 271 non-responders out of which 126 eligible individuals responded and were screened with an additional 35 recruited. The 67 eligible participants were randomized to a control group (n=34) that received standard printed copies of Canada's Food Guide and Diabetes Canada's GI resources or an intervention group (n=33) that received those same materials, plus an online platform with six self-directed learning modules (Figure 4.1). In addition to the web-based platform, the intervention group also received a printed copy of, "The Shopper's Guide to GI Values: The Authoritative Source of Glycemic Index Values for More Than 1,200 Foods" [192]. The web-based platform housed six self-directed learning asynchronous learning modules that were to be completed over 12-weeks. Each module focused on a different aspect of GI education and included a video featuring a Registered Dietitian, links to reliable websites; asynchronous chat rooms, and module-content-related quizzes. The website was managed by a trained research assistant. The chat room discussions were moderated under the supervision of the co-investigators: KS, a researcher and Registered Dietitian and researchers, STJ and JAJ. Evidence-based GI content included GI values of foods, low-GI shopping tips, recipes, cooking tips and advice for eating out. Participants gained access to a new module every 2-weeks. Based on individual preference, additional support was provided through email, text message, phone calls, or mail to reinforce participants' learning. Health Research Ethics Boards at University of Alberta (file: Pro00068291) and Athabasca University (file: 22355) approved the study protocol and all participants provided written informed consent.

4.3.2 Socio-Demographic, Clinical and Anthropometric Measures

Demographic information including age, sex, marital status, education, employment status, income, and personal history of CVD risk factors (e.g., smoking), and time since T2D diagnosis were assessed. Clinical outcomes included glycated hemoglobin A1c, systolic blood pressure (SBP) and lipid profile. Capillary blood samples (35μL) were collected from participants to assess HbA1c using previously validated point-of-care testing device (DCA Vantage) [41] and lipid profile (Cholestech LDX). Systolic blood pressure was measured according to standard protocols using (BPTru) [42]. Weight, height, and waist circumference were assessed according to the Canadian Physical Activity, Fitness and Lifestyle Appraisal procedures [53]. Body weight in kilograms and height in meters were measured for each subject with light clothing and no shoes. Body weight was measured to the nearest 0.1 kg with a portable digital scale (Tanita BWB-800S). Height was measured using a stadiometer (Tanita HR-100). Waist circumference was measured to 1 mm at the top of the iliac crest using a spring-loaded Gulick anthropometric tape (FitSystems Inc., Calgary, AB). Regular, monthly quality assurance checks (calibration) were conducted on the point-of-care devices and scale. With the exception of demographics, all measures were assessed at baseline and at 3 months

4.3.3 Dietary Assessment

Food intake was assessed for all participants at baseline and at 3 months using a 3-day food record. Three-day food records are valid and reliable for capturing dietary behaviour change by asking participants to record their food consumption as they eat [39]. All participants were given detailed instructions on how to fill out the 3-day food record, and asked to record, in as much detail as possible, descriptions of foods and beverages consumed over 2 week days and 1 weekend day. Colour photographs were provided to assist participants with estimating and recording appropriate portion sizes of foods and beverages they consumed in the 3-day food record logbooks. Pictures showing sample portions sizes of foods measured against items including a finger, palm of a hand, and a hockey puck were included and participants were encouraged to choose photographs that best represented their portion sizes or specify if they consumed more or less. Mean daily food consumption and nutrient intakes were estimated using the Food Processor Diet Analysis and Fitness Software (ESHA Research, Salem, USA) at baseline and 3 months using the Canadian nutrient file. Daily average GI and glycemic load (GL) were calculated for all carbohydrate-containing foods identified from the 3-day food records using published international GI tables [33, 40].

4.3.4 Glycemic Index and Glycemic Load Estimation

All carbohydrate-containing foods identified from the 3-day food records were assigned GI values corresponding to the best geographic and botanical matches in published International Table of Glycemic Index and Glycemic Load Values [151, 165] or the updated University of Sydney online database (www.glycemicindex.com). GI values were averaged for foods having more than one GI value from very similar matches. As the International Table and the University of Sydney online databases do not provide an exhaustive entry of glycemic data for every food, in instances where foods could not be matched directly to those in the International Tables/online database, they were calculated from Estimated Glycemic Load [166] or matched to listed foods with similar characteristics (ingredients, composition, and physical properties) based on all information available to HMA, a trained dietitian and from his subjective experience and knowledge of foods [113, 167, 168]. As recommended [167-169], daily average GI and GL were calculated as follows:

$$\text{Total Dietary GL} = \left(\sum_{X=1}^{n} GI_x * CHO_x\right) / 100$$

$$\text{Total Dietary GI} = \left(\sum_{x=1}^{n} GI_x * CHO_x\right) / \sum_{x=1}^{n} CHO_x$$

where for *n* foods in the diet, GI*x* is the GI of food *x*, CHO*x* is the gram weight of available carbohydrate (total CHO - dietary fibre) consumed from food *x*, and ΣCHO*x* is the total amount of available carbohydrate eaten over the 3 days [17].

4.3.5 Glycemic Index-Related Dietary Behaviour Change Assessment

Pre- and post-intervention GI concept knowledge, understanding, intention to eat low-GI foods, and self-efficacy were assessed and quantified using questions adapted from previous studies [68, 180]. Net GI-related dietary behaviour change due to the intervention was determined using composite summative rating scales developed from individual items and scale reliability coefficient (Cronbach's alpha) were calculated [193].

Knowledge regarding benefits of the GI for overall health was estimated using two items: 1) How would you describe your knowledge of the glycemic index concept? 2) How good are low glycemic index carbohydrates for your health? Confidence (self-efficacy) for identifying and consuming low-GI foods was assessed using the following items: 1) What is your confidence level when identifying low glycemic index foods? 2) What is your confidence level for regularly consuming low glycemic index foods? Responses for these items were scored on a 5-point scale with options: *Very poor; Poor; Unsure; Good;* and *Very Good*. Understanding of GI concept was assessed using two items. 1) "How would you describe your understanding of the glycemic index concept?" Response options included *Never heard of it; Heard of it but didn't understand; Heard of it and tried to make changes; Heard of it and made changes; Heard of it and have good understanding*. 2): "How would you rank your understanding of the glycemic index?" Response options were: *Very good; Good; Fair; Poor;* and *Very Poor* and were reverse scored. Diabetes-related GI knowledge consisted of a summative score of four individual items 1) Eating low glycemic foods more often may improve my blood sugar readings; 2) Choosing low glycemic index foods more often is a lifestyle change that helps to better manage my diabetes; 3) I am afraid eating low glycemic index foods more often may cause high blood sugar readings; 4) If I eat low glycemic index foods more often, I can eat as many high glycemic index foods as I want. Responses ranged from *strongly disagree* to *strongly agree* on a 7-point unipolar scale with the last two questions negatively scored. A behavioural "intention to consume low-GI foods" score was also derived by summing three individual items, with a 7-point unipolar agreement scale: 1) I intend to eat low glycemic index foods more often in the next two weeks; 2) I want to eat low glycemic index foods more often in the next two weeks; 3) I plan to eat low glycemic index foods more often in the next two weeks [68].

Based on the Trans-Theoretical Model [60, 61], participants also provided responses to indicate their stage of readiness (i.e., pre-contemplation, contemplation, preparation, action and maintenance) in relation to low-glycemic index food consumption. Stage occupation for low-GI food choices were assessed using a composite summative score of two items adapted from a previous measure [170]. The questions, "Do you consistently avoid eating high Glycemic Index foods?" and "Do you normally choose low Glycemic Index foods?" both had 5 response options: 1) *No, and I do not plan to do so in the next 6 months* (pre-contemplation); 2) *No, but I was thinking about doing so in the next 6 months* (contemplation; 3) *No, but I planned to in the next 30 days* (preparation); 4) *Yes, but I have only begun in the past 6 months* (action); 6) *Yes, and I have been doing so for longer than 6 months* (maintenance). These were merged into a single item: "Do you normally choose low-GI instead of high-GI foods?" Participants' stage occupation for low-GI choices were categorised into three groups: Pre-Action (pre-contemplation, contemplation, or preparation), Action/Maintenance and No response. Participants' awareness of the GI concept was assessed using a question adapted from a previous measure [16] "Do you know what the Glycemic Index is?" with response options "Yes" or "No".

4.4.0 Statistical Analyses

Descriptive statistics were computed to determine the nature of the data and to test for assumptions. An *a priori* planned intention to treat approach was used to evaluate change in the primary and secondary outcomes using analysis of covariance (ANCOVA) [194]. Change in mean daily GI intake from baseline to 3 months was our primary outcome measure. In this ANCOVA model for the primary analysis, 3-month GI was the dependent variable, with study group (intervention or control) and baseline GI values as the covariates. Participant characteristics (e.g. sex, education, and income) and clinical factors assessed at baseline were secondarily evaluated as potential covariates in the ANCOVA, using generalized linear mixed-model analysis (GLMM). Based on our previous research [17], a sex-stratified ANCOVA was also completed.

For some of the secondary outcomes, composite summative rating scales developed from individual items were used to examine the net change in GI-related dietary knowledge, intention and self-efficacy due to the intervention. Cronbach's alpha (α) was calculated to measure internal consistency (reliability) of items included in the composite scores. Scale reliabilities (α) for baseline and 3months follow up respectively were: GI knowledge (overall health) 0.63 and 0.63; Confidence (self-efficacy) for identifying and consuming low-GI foods 0.87 and 0.90; Understanding of GI concept 0.87 and 0.90; Diabetes related knowledge of GI 0.88 and 0.77; Intention to consume low-GI foods 0.95 and 0.94; and Stages of Change 0.96 and 0.75. Spearman's correlation of the two items included in the Stages of Change scale showed a strong positive monotonic relationship (rs =0.92), indicating that choosing low-GI foods is associated with avoiding high GI foods and suggests unidemensionality.

The magnitude of the differences in changes in all outcomes between intervention and control were calculated, along with 95% confidence intervals (CI). Standardized effect sizes (Cohen's d) were also calculated as an estimate of the effect size, with 0.2 interpreted as small, 0.5 moderate and 0.8 as large changes [173]. McNemar's test was used to assess if the observed changes in the proportion (%) of participants after the intervention or control condition who were aware of GI concept or for stage occupation (Pre-Action, Action/Maintenance) for consuming low-GI foods were due to chance. All statistical analyses were performed using STATA (version 12.1, StataCorp, College Station, Texas, USA) and p-values <0.05 were considered statistically significant.

4.4.1 Statistical Power

Given available resources (i.e. budget, study duration), the labour intensity of the 3-Day Food Record dietary assessment method, and previous studies regarding the efficacy of GI-based nutrition education and glycemic control [109, 180] and meta-analysis of studies on low-GI diets and diabetes management [103], a power analyses demonstrated that an initial sample size of 66 (with 33 in each arm) allowing for 30% attrition resulted in a power of 0.90 (alpha =0.05, two tailed) for detecting an estimated treatment effect size of d = 1.

4.5.0 Results

4.5.1 Participant Characteristics and Missing Data

A total of 67 eligible adults recruited from the ABCD Cohort [161] living in Edmonton (N=485) participated in the HEALD-GI trial. Participant recruitment, randomization, and retention have been described elsewhere [191] and summarized in (Figure 4.1). The control and intervention groups appeared to be similar on most characteristics at baseline (Table 4.1), although more people in the intervention group reported being retired. Participants were 64% men; mean age 69.5 (9.3) years, with mean diabetes duration of 19.0 (13.7) years, BMI 30.1 (5.7) kg/m^2, and HbA1c 7.1 (1.2)% at baseline (Table 4.1).

Participants, (N=67) were over-recruited to compensate for an estimated 30% attrition per arm [191]. Six participants (n=2 intervention, n=4 control) who did not provide baseline primary outcome data by returning 3-Day Food Records were excluded from all analyses thereby reducing the number of those included in the final analyses to 61 (n=31 intervention, n=30 control). No differential attrition was noted with regards to participant characteristics (i.e., age, education, or sex) and the six individuals excluded from final analyses were not different from the overall randomized sample. For the main analysis, 67% (n=41) completed all baseline and follow-up measurements (intervention n=23, control n=18). Last value carried forward imputation was carried-out for 20 participants (intervention n=8 (26%) and control group n=12 (40%)) (Appendix 4.1) in line with the outlined *a priori* analysis.

4.5.3 Dietary and Clinical Outcomes

The primary outcome of interest, change in mean (standard deviation, SD) daily GI from baseline to 3 months, was a reduction of -2.79 (-7.77) GI units for those randomized to the intervention compared to an increase of 0.76 (6.48) GI units in the control group, for an overall between group adjusted mean difference in change of -3.77 (95% CI: -6.95; -0.58; p=0.02; effect size (d=-0.53)) (Table 4.2). Secondary adjustment by participant characteristics to examine potential differences in effects associated with age, sex, education, employment status, or income yielded similar results.

Similarly, small to modest effect sizes favoring the intervention group compared to controls were found for reductions in glycemic load, calories, and fat intakes per day, all of which were not statistically significant. A statistically significant adjusted difference in protein consumption of -11.38 g/day (95% CI: -23.18, 0.43; p=0.02; effect size (d=-0.76)) was observed for those randomized to the intervention compared to control. The overall results did not reveal significant differences between the intervention and control on any of the clinical outcomes after the intervention (Table 4.2).

4.5.4 Mediators of Glycemic Index-Related Dietary Behaviour Change

Self-reported GI-related knowledge, understanding, and self-efficacy to consume low-GI foods increased across all scales ($p < 0.01$) with moderate to large effect sizes ($d=0.56$ to $d=0.92$) among those randomized to the intervention group, compared with the control group (Table 4.3). A borderline increase in intention to consume low-GI foods ($p=0.05$) with a small to moderate effect size ($d=0.39$) was observed for those randomized to the intervention compared to control (Table 4.3). A proportional increase in awareness of GI concept from 61% to 94% ($p=0.01$) was seen in the intervention group versus 60% to 83% ($p=0.46$) in the control group. Similarly, a statistically significant proportional increase in Action/Maintenance stage occupation for consuming low-GI foods from 48% to 81% ($p<0.01$) was observed in the intervention group versus 43% to 50% increase ($p=0.47$) in the control group (Table 4.4).

4.6.0 Discussion

The primary goal was to evaluate the effectiveness of a GI-targeted nutrition education on GI-related dietary intake and knowledge among adults with T2D using a pragmatic randomized controlled trial. We showed that the web-based education intervention led to a reduction in mean daily GI intake. To support the reduction in mean daily GI intake, knowledge, understanding, and confidence (self-efficacy) for consuming low-GI foods were also found. Participants' awareness of GI concept and readiness to consume low-GI foods as indicated by their stage occupation was consistent with previous findings that individuals who were aware of the low-GI concept were more likely to put it into action, thereby transitioning to the Action/Maintenance Stage of change

[17]. Albeit moderate, the direction of these changes is consistent with the behaviour change theory backing the intervention, in that a change in mean GI intake was possibly mediated by an increase in GI-related dietary knowledge and self-efficacy. Findings from this trial are important given that to the best of our knowledge, this was the first RCT to show a reduction in mean daily GI intake using a web-based platform among older adults with T2D.

Outlining effective approaches for promoting the GI concept among individuals with T2D in line with clinical guidelines has been problematic in Canada due to debates over clinical utility of GI, inconsistencies in teaching the GI concept by registered dietitians [18, 19], and inadequate nutrition care [15]. Consequently, GI-concept knowledge translation gaps exist and hinder additional improvements in glycemic control, cardiovascular risk factors, beta cell function and reduced need for anti-hyperglycemic agents [39, 40, 103-111] associated with the adopting the low-GI dietary pattern as part of a healthy eating lifestyle. Results from this study therefore contribute strong scientific evidence regarding an alternative, effective approach to overcoming some of the barriers associated with the GI knowledge translation.

The effectiveness of the HEALD-GI targeted nutrition intervention in successfully improving carbohydrate quality without upsetting other important aspects of participants' intakes is worth considering. Replacing high with low-GI foods without adequate knowledge and understanding of GI concept as part of overall healthy eating practices can increase fat intakes [109, 179] given that foods such as ice cream which have high fat and protein contents tend to have lower GI values [10, 169]. Burani and Longo [180] noted that some participants haphazardly followed a low-GI diet until their GI knowledge was improved through a GI concept targeted education. However, participants in this study reported reduction in their mean daily GI without changing their overall dietary calorie intake due to a reduction or increment in the quantity or qualitative aspects of the diet. Moreover, significant reduction in mean daily protein intake was observed, which is different from the excessively high protein intakes previously reported among the same cohort of ABCD participants [17]. These suggest that this proactive web-based GI-targeted nutrition intervention, which targets overall diet quality, was potent in isolating a specific component of the diet and changing it without undesirably altering the overall diet. Also, given the high levels of nonattendance at traditional face-to-face consultations among people with chronic conditions such as diabetes [195], it is worth exploring this web-based approach, which is able to overcome the barriers of geographical isolation and transportation, limited parking, poor access and unfavorable operating hours of to health facilities known to influence nonattendance [80, 195].

Although this study has shown potential for providing education and self-management support that facilitates and sustains lifestyle changes for best health outcomes, findings from this study need to be interpreted in the context of the following limitations. Importantly, we observed a differential loss to follow-up, which was higher in the control group but was compensated for using "last value carried forward" imputation procedure given our a priori, planned intention-to-treat analytic approach. This may have introduced a potential systematic difference (i.e., bias) in the assessment of GI, leading to an overestimation of the observed change, and compromised the internal validity of findings. Another limitation could be the use of the 3-DFR, a self-report measures of dietary behaviour change, which may be prone to social desirability bias [138, 139]. However, in the context of a randomized study design, any biases in dietary assessment would equally apply to intervention and control groups, thereby preserving the internal validity, and only affect the generalizability (i.e., external validity) of the results. While the reduction in mean daily GI intake in this study may have been smaller than anticipated [191] with a moderate effect size, the change in behaviour was congruent with improvements in knowledge, and self-efficacy. From a research design perspective, with more resources, this study could be replicated, perhaps with a larger, more diverse sample drawn from a general population of people whose GI is not already low to yield a smaller variability in the GI of the pooled sample for a larger effect size. Nonetheless, being the first GI knowledge translation intervention of its kind among people with diabetes in Canada, these findings provide us with the opportunity to learn more about the effects of such lifestyle interventions.

Using the 3-DFR together with the Canadian Nutrient File to capture dietary intakes and generate nutrient intakes is a key strength of this study for the following reasons. Besides the strong correspondence between data from the 3-DFR with self-reported practices observed, the 3-DFR reduces challenges with recall bias, does not require an interviewer for its administration and was more likely to have captured greater coverage of usual dietary intakes [130]. Another key strength of this study is the pragmatic clinical trial design, which is most likely to reflect variations between patients that occur in real clinical practice and thus, better inform clinical and health policy decisions [196]. Considering the small sample size however, a larger more diverse sample may be needed to further understand participant characteristics and mediators that led to the observed findings for better generalization. Finally, given the cost of developing a web-based educational intervention and accessibility, future assessments may also need to compare the web-based approach with face-to-face GI-targeted nutrition education to further compare its true effects.

4.7.0 Conclusion

The GI concept may be beneficial for improving health outcomes of people with diabetes. However, lifestyle behaviours are hard to change, especially in participants who are already consuming a low-GI diet and thus have very little room for change. Therefore, the significant reduction in mean daily GI intake observed, in addition to improvement in potential mediators, (i.e. knowledge, self-efficacy, intention), suggests that this web-based intervention has promise for overcoming GI-related and other dietary knowledge translation gaps. Future studies involving larger, more diverse sample may therefore be needed to expand on the feasibility and usefulness of this intervention in other populations.

Table 4.1: Participant Characteristics

	All* (n=67) (mean, SD) or (%)	**Intervention*** (n=33) (mean, SD) or (%)	**Intervention**** (n=31) (mean, SD) or (%)	**Control*** (n=34) (mean, SD) or (%)	**Control**** (n=30) (mean, SD) or (%)
Sex (Males) (%)	43 (64)	20 (61)	19 (61)	23 (68)	19 (63)
Age (years)	69.5 (9.3)	70.7 (9.0)	71.1 (9.1)	68.4 (9.6)	68.6 (9.3)
Marital status, no. (%)					
Married or common law	47 (70)	20 (61)	20 (65)	27 (79)	24 (80)
Not married (never married, widowed, divorced or refused to answer)	20 (30)	13 (39)	11 (35)	7 (21)	6 (20)
Ethnicity, no. (%)					
Caucasian	62 (93)	30 (91)	28 (90)	32 (94)	28 (93)
Non-Caucasian	5 (7)	3 (9)	3 (10)	2 (6)	2 (7)
Education, no. (%)					
High school and less	21 (31)	12 (9)	8 (26)	12 (35)	10 (33)
College and higher	46 (69)	24 (73)	23 (74)	22 (65)	20 (67)
Employment no. (%)					
Employed	10 (15)	2 (6)	1 (3)	8 (23)	6 (20)
Unemployed	5 (7)	1 (3)	1 (3)	4 (12)	4 (13)
Retired	52 (78)	30 (91)	29 (94)	22 (65)	20 (67)
Annual Household Income (CAD$)					
<$40,000	8 (12)	3 (9)	3 (10)	5 (15)	5 (17)
$40,000 – $79,999	30 (45)	16 (49)	15 (48)	14 (41)	13 (43)
≥$80,000	20 (30)	7 (21)	6 (19)	13 (38)	10 (33)
Do not know/refused to answer	9 (13)	7 (21)	7 (23)	2 (6)	2 (7)
Diabetes duration (years)	19.0 (13.7)	20.0 (11.7)	20.5 (11.7)	18.0 (15.5)	18.6 (16.2)
A1c (%)	7.1 (1.2)	7.0 (1.4)	7.0 (1.5)	7.1 (0.9)	7.1 (0.9)
Total cholesterol (mmol/L)	4.4 (1.0)	4.3 (1.0)	4.3 (1.0)	4.5 (0.9)	4.5 (0.9)
HDL (mmol/L)	1.3 (0.4)	1.4 (0.4)	1.4 (0.4)	1.3 (0.4)	1.3 (0.4)
TC/HDL Ratio	3.6 (1.5)	3.3 (0.9)	3.2 (0.9)	3.9 (1.9)	4.0 (2.0)
Systolic BP (mmHg)	127.9 (12.4)	127.7 (9.9)	127.4 (10.1)	128.2 (14.6)	126.9 (14.1)
Diastolic BP (mmHg)	70.1 (10.6)	69.8 (8.1)	69.3 (7.7)	70.5 (12.8)	69.7 (12.1)
Resting Heart Rate (bpm)	77.8 (14.5)	78.8 (15.3)	78.4 (15.6)	76.8 (13.9)	77.3 (14.3)
Body Mass Index (kg/m^2)	30.1 (5.7)	28.0 (5.1)	27.4 (4.6)	32.0 (5.6)	31.8 (5.7)
Waist Circumference (cm)	107.4 (16.1)	102.5 (15.5)	100.8 (14.4)	112.2 (15.4)	111.2 (15.8)

*Participants who were randomized.
**Participants who completed baseline measurements and included in analyses.

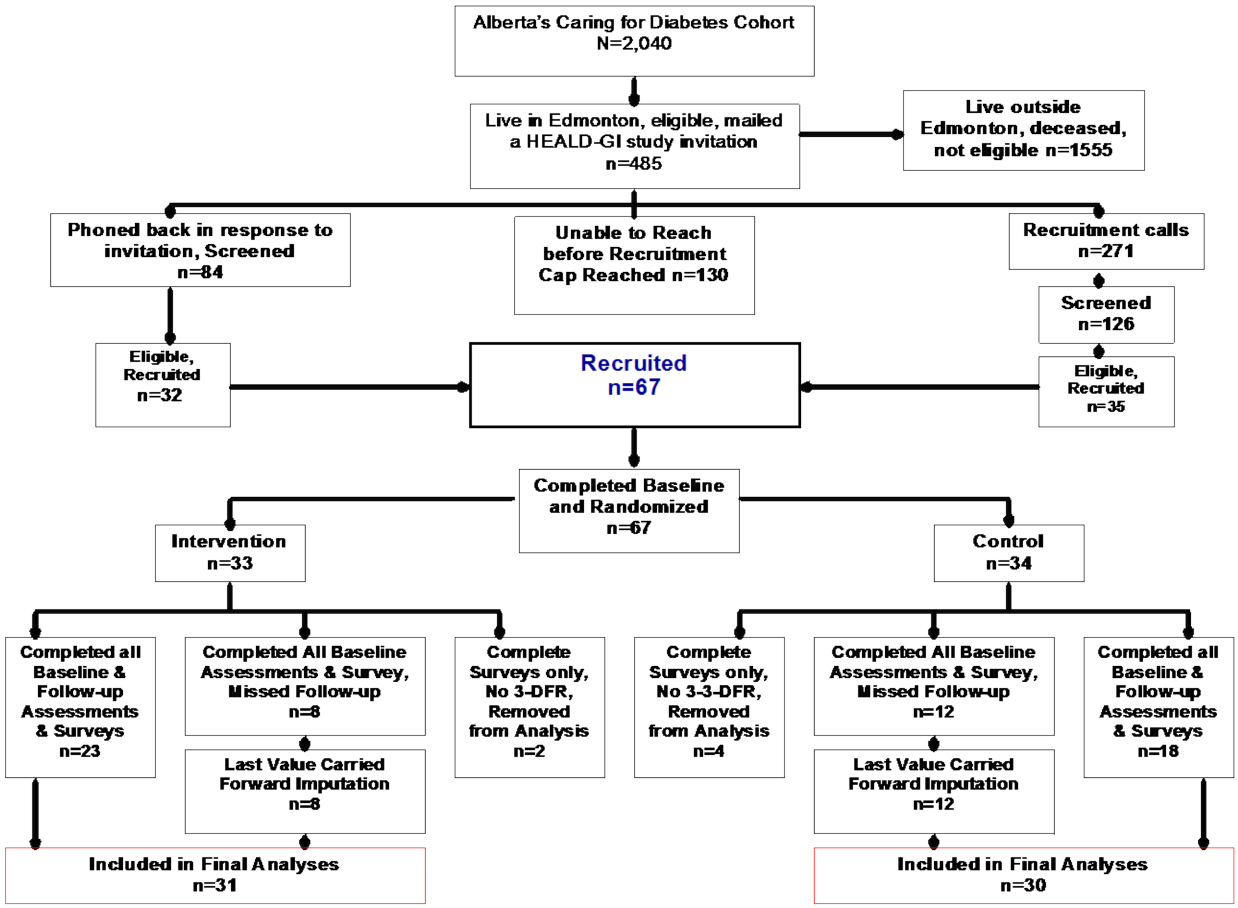

Figure 4.1: Flow diagram of participant recruitment, treatment allocation, and retention

Table 4.2: Dietary and Clinical Outcomes

	Intervention (n=31)		Control (n=30)		Difference	Effect Size	P value
	Baseline mean (SD)	$\Delta_{Intervention}$ mean (SD)	Baseline mean (SD)	$\Delta_{Control}$ mean (SD)	(Adjusted) mean (95% CI)	$\frac{\Delta_{Int} - \Delta_{Cont.}}{SD_{pooled}}$	
Glycemic Index	48.60 (7.79)	-2.79 (7.77)	49.06 (7.94)	0.76 (6.48)	-3.77 (-6.95, -0.58)	-0.53	0.02
Glycemic Load (g)	118.77 (38.61)	-8.42 (38.30)	105.07 (42.72)	1.36 (29.67)	-4.56 (-20.62, 11.50)	-0.13	0.57
Calories (kcal)	2358.27 (575.18)	-26.22 (511.49)	2003.79 (650.69)	107.79 (371.70)	-54.60 (-284.53, 175.34)	-0.12	0.64
Carbohydrate (g/day)	271.91 (70.06)	-3.74 (60.88)	236.76 (98.60)	1.33 (54.42)	2.40 (-26.33, 31.13)	0.04	0.87
Fat (g/day)	95.17 (37.38)	-1.35 (28.71)	79.95 (28.20)	7.46 (24.63)	-6.10 (-19.97, 7.78)	-0.23	0.38
Protein (g/day)	102.18 (34.57)	-1.10 (26.52)	87.66 (34.68)	13.76 (20.67)	-11.38 (-23.18, 0.43)	-0.76	0.02
Fibre (g/day)	28.04 (9.80)	-0.57 (7.22)	24.42 (17.86)	0.85 (5.79)	-1.07 (-4.42, 2.27)	-0.16	0.52
HbA_1c (%)	7.03 (1.47)	-0.23 (0.32)	7.07 (0.92)	-0.21 (0.36)	-0.01 (-0.19, 0.16)	-0.03	0.89
Total Cholesterol (mmol/L)	4.28 (1.02)	-0.002 (0.41)	4.51 (0.95)	-0.18 (0.63)	0.18 (-0.09, 0.46)	0.34	0.19
HDL (mmol/L)	1.39 (0.40)	0.03 (0.22)	1.26 (0.40)	-0.01 (0.19)	0.05 (-0.06, 0.16)	0.24	0.34
TC/HDL Ratio	3.23 (0.91)	-0.05 (0.62)	3.99 (2.02)	-0.09 (0.52)	0.01 (-0.29, 0.31)	0.02	0.96
BMI (kg/m^2)	27.36 (4.56)	-0.17 (0.48)	31.75 (5.68)	-0.02 (0.72)	-0.09 (-0.44, 0.25)	-0.15	0.59
Waist Circumference (cm)	100.80 (14.43)	-1.29 (2.49)	111.15 (15.79)	-0.50 (2.69)	-0.87 (-2.28, 0.55)	-0.34	0.23
Systolic BP (mmHg)	127.39 (10.06)	1.24 (11.65)	126.94 (14.08)	2.33 (9.17)	1.27 (-3.55, 6.10)	-0.12	0.60
Diastolic BP (mmHg)	69.27 (7.73)	-1.67 (6.83)	69.70 (7.73)	-1.37 (5.18)	-0.41 (-3.26, 2.45)	0.06	0.78
Resting Heart Rate (bpm)	78.39 (15.55)	-4.99 (9.71)	77.32 (14.28)	-2.78 (8.40)	-1.87 (-5.89, 2.14)	-0.21	0.35

Data are means ± SD. Significance set at $p < 0.05$ (for ANCOVA comparing intervention and control).

Table 4.3: Glycemic Index Knowledge, Understanding, Intention, and Self-Efficacy (Confidence) [1]

	Intervention (n=30)		Control (n=30)		Difference	Effect Size	P value
	Baseline mean (SD)	$\Delta_{Intervention}$ mean (SD)	Baseline mean (SD)	$\Delta_{Control}$ mean (SD)	(Adjusted) mean (95% CI)	$\frac{(\Delta_{Int} - \Delta_{Cont.})}{SD_{pooled}}$	
GI Knowledge (Overall health)	7.63 (1.92)	1.23 (2.16)	7.97 (1.56)	-0.10 (1.09)	1.13 (0.43, 1.83)	0.67	<0.01
GI Knowledge (Diabetes specific)	24.27 (4.10)	2.17 (4.11)	25.3 (2.94)	-0.67 (3.46)	2.14 (0.59, 3.69)	0.56	<0.01
Understanding of GI Concept	6.37 (2.30)	2.13 (2.11)	6.33 (2.01)	0.37 (1.43)	1.65 (0.85, 2.44)	0.92	<0.01
Intention to consume low-GI foods	15.90 (4.49)	1.97 (4.70)	16.77 (3.45)	-0.13 (2.85)	1.52 (0.03, 3.02)	0.39	0.05
Self-efficacy for identifying and consuming low-GI foods	6.5 (2.03)	1.43 (1.85)	6.6 (2.31)	0.10 (1.60)	1.29 (0.51, 2.07)	0.75	<0.01

Data are means ± SD. Significance set at $p < 0.05$ (for ANCOVA comparing intervention and control).

[1] Measures adapted from Burani and Longo (2006)[180] and Watanabe et al (2015)[68]

Table 4.4: Awareness (Knowledge of Glycemic Index concept) and Stages of Change for low Glycemic Index Food Choices

	Intervention (n=31)		Control (n=30)	
	Baseline n (%)	Follow Up n (%)	Baseline n (%)	Follow Up n (%)
Do you know what GI is?				
Yes	19 (61)	29 (94)	18 (60)	25 (83)
No	12 (39)	2 (6)	12 (40)	5 (17)
P value	**<0.01**		**0.46**	
Stages of Change				
Pre-Action	16 (52)	6 (19)	17 (56)	15(50)
Action	15 (48)	25 (81)	13 (43)	15 (50)
P value	**<0.01**		**0.47**	

Data are means ± SD.
Significance set at $p < 0.05$ (for McNemar test comparing change in proportion).

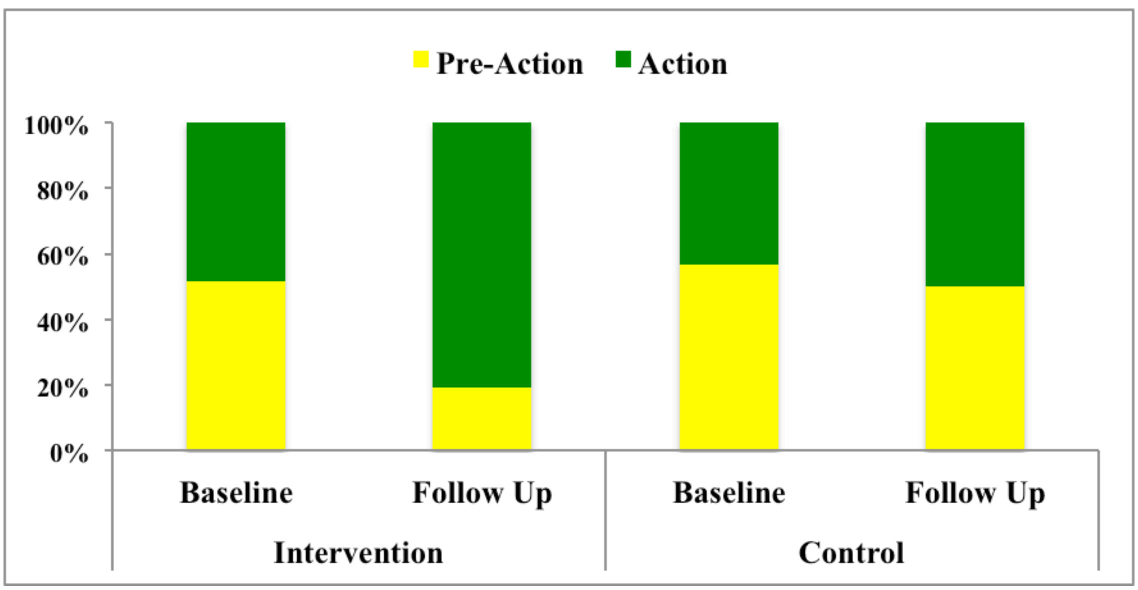

Figure 4.2: Stage occupation for consuming low-GI foods

Data are means ± SD.
Significance set at $p < 0.05$ (for McNemar test comparing change in proportion).

Appendix 4.1: Participation and Retention Data

	Intervention (n=33)	Control (n=34)	Total (n=67)	Analysis (n=61)
	n (%)	n (%)	n (%)	n (%)
Completed both surveys and 3-DFR	23 (70)	18 (53)	41 (61)	41 (67)
Completed both surveys and only baseline 3-DFR	4 (12)	8 (23)	12 (18)	12 (20)
Completed baseline surveys and 3-DFR, missed follow-up	4 (12)	4 (12)	8 (12)	8 (13)
Completed both surveys only, no 3-DFR	1 (3)	3 (9)	4 (6)	0 (0)
Completed baseline surveys only (no follow-up, no 3-DFR)	1 (3)	1 (3)	2 (3)	0 (0)

Appendix 4.2: Print, Text Message, Email, HEALD-GI Website, and Chat Room Use

	Participants (n=33)
	n (%)
Had access to GI book (The Shopper's Guide to GI Values)	33 (100)
Chose text message (SMS) as preferred medium for receiving alerts and reminders	1 (3)
Communicated with research team within 12-week intervention period via email	33 (100)
Chose email as preferred medium for receiving alerts and reminders	32 (97)
Accessed HEALD-GI intervention website and completed at least 1 Module	31(94)
Completed 5 out of 6 Modules, enough to enhance GI concept knowledge	28 (85)
Accessed HEALD-GI website and engaged in chat room discussions (average of 2 chats)	8 (24)

Appendix 4.3: HEALD-GI Intervention Module Engagement Data

HEALD-GI Intervention Modules	Participants (n=33)
	n (%)
Module 1: General healthy eating for diabetes	30 (91)
Module 2: Summary of the Glycemic Index Concept	29 (88)
Module 3: Identifying, choosing, and shopping low-GI	29 (88)
Module 4: Low-GI Recipes, Menus and Meal Planning	28 (85)
Module 5: Guidelines for Eating Out and Snacking	29 (88)
Module 6: GI concept and general diabetes self-management and healthy lifestyles	25 (76)

Appendix 4.4: Links to HEALD-GI Web-Based Intervention (Upon Request)

Home (Landing page): http://healdgi.shoutcms.net/home

About the HEALD Program: https://healdgi.shoutcms.net/about-the-heald-learning-program

Module 1: https://healdgi.shoutcms.net/module-1-general-healthy-eating-for-diabetes

Module 2: https://healdgi.shoutcms.net/module-2-summary-of-the-glycemic-index-concept

Module 3: https://healdgi.shoutcms.net/module-3-identifying-choosing-and-shopping-low-gi

Module 4: https://healdgi.shoutcms.net/module-4-low-gi-recipes-menus-and-meal-planning

Module 5: https://healdgi.shoutcms.net/module-5-guidelines-for-eating-out-and-snacking

Module 6: https://healdgi.shoutcms.net/module-6-gi-concept-and-general-diabetes-self-management

CHAPTER 5

Computer proficiency and web-based lifestyle intervention use among older adults with type 2 diabetes

5.1.0 Abstract

Background: Web-based information technologies can serve as an accessible and potent medium for engaging, educating, and empowering individuals with chronic diseases such as type 2 diabetes (T2D). Participants, however, need to be proficient in certain domains of computer and Internet use in order to access and utilize available web-based interventions for chronic disease management. Older adults are most likely to have chronic diseases, and may be less proficient, thus limiting access to such educational technologies.

Objective: To assess baseline computer proficiencies of older adults with T2D prior to participating in a web-based lifestyle intervention program.

Methods: A sample of older adult T2D patients participating in an educational intervention study (N=67) completed a validated Computer Proficiency Questionnaire (CPQ) for evaluating their competencies in the domains of computer basics, printing, communication, Internet, calendaring software and multimedia use. Average responses to items on the 5-point scale were summed to produce subscale and composite CPQ scores. Socio-demographic information was collected by questionnaire and the use of email, website and a chat room during a 12-week lifestyle intervention were assessed. Linear regression was used to determine relevant predictors of computer proficiency and t-tests were used to compare mean differences between CPQ scores by age and education.

Results: Participants were 64% men; mean age 69.5 (9.3) years, with a mean diabetes duration of 19.7 (14.4) years. The CPQ subscales demonstrated excellent internal consistency reliability, with Cronbach's alpha coefficients ranging from 0.89 to 0.91. Average subscale scores were: basic computer skills (4.9±0.3), Internet use (4.3±1.0), and communication (4.3±0.7) and overall composite CPQ score was 25.4 ± 4.9 out of 30.0. Age and education were independently associated with the composite CPQ score ($p<0.001$).

Conclusion: Computer proficiency was very high among this sample of older adults with T2D, which helps to explain their use of the web-based intervention at baseline. Healthcare providers supporting this population might consider augmenting their services with web-based diabetes self-management but should consider the individual level of computer and technology proficiency.

***Keywords*:** Computer proficiency, older adults, web-based interventions, type 2 diabetes

Note: A version of this chapter has been submitted for review as: Avedzi H, Soprovich AL, Alghamdi A, Storey K, Johnson JA, Johnson ST. (2018) Computer proficiency and web-based lifestyle intervention use among older adults with type 2 diabetes. (Health Education & Behaviour)

5.2.0 Introduction

Living a healthy, productive life with diabetes hinges on the ability to effectively carry out a range of daily self-management activities including healthy eating, physical activity, medication administration, blood glucose monitoring, and foot care. Effective self-management improves key outcomes including glycemic control, dietary habits, diabetes complications, and quality of life for people with T2D [197-199]. Providing tools and support to increase self-efficacy for daily diabetes self-management enables patients to make the right choices for optimal health outcomes [77]. Therefore, healthcare providers and researchers supporting people with T2D continue to explore ways to leverage emerging, widely accessible, cost-effective, and efficient approaches for delivering self-management education and support.

Information technology (IT) tools including mobile, computer and web-based applications such as websites and virtual environments, have revolutionized traditional approaches for engaging, educating, and empowering individuals with chronic diseases such as diabetes [21, 200-203]. Internet-based educational programs have proved to change behaviours such as healthful eating, glycemic control and overall health status of people with diabetes [20, 21]. Internet-based approaches have the potential to overcome barriers of distance, limited access, scheduling logistics, and limited healthcare personnel (e.g. Registered Dietitians and certified diabetes educators) [20, 21]. In addition, IT tools such as websites; chat rooms, social networking sites (e.g. Facebook), and text messaging applications allow some degree of personalization while connecting with other users [204, 205]. Given these benefits, governments and private organizations are increasingly investing in strategies using IT tools for health promotion, disease prevention, and improving healthcare delivery [206]. The U.S. government has created action plans to expand health IT and consumer electronic health tools, aimed at increasing active participation of individuals for improving health and healthcare [207]. Private organizations also use IT tools to enhance service delivery and health outcomes for users [208, 209]. This makes IT tools pertinent to wellbeing and modern healthcare.

An evidence-based healthy eating education program was designed to meet the educational needs of adults with T2D using appropriate, effective, and widespread web- and mobile-based IT tools [191]. The aim was to offer a viable prospect for promoting diabetes-related dietary concepts to bridge a well documented knowledge translation gap [14, 191]. Patterns of information technology usage in older adults has been shown to vary significantly by socio-demographic factors such as age, education, income, race/ethnicity, and health status including physical and mental [21, 210, 211]. Given that uptake of this intervention hinged greatly on the users' computer and Internet proficiencies, we assessed baseline computer proficiency of adults living with diabetes in Edmonton, Alberta, Canada prior to participating in the HEALD-GI trial [191].

5.3.0 Methods

The Healthy Eating and Active Living Glycemic Index (HEALD-GI) trial (ClinicalTrials.gov Identifier: NCT03037099), designed to evaluate the effectiveness of a 12-week GI-targeted nutrition education program among adults with T2D in Edmonton, Alberta, has been described elsewhere [191]. Briefly, sixty-seven eligible participants drawn from the Alberta Caring for Diabetes (ABCD) Cohort [161] were randomized into two equal groups using a pragmatic randomized controlled trial design. Group 1 (control, n=34) received standard printed copies of Canada's Food Guide and Diabetes Canada (formerly Canadian Diabetes Association) GI resources. Group 2 (intervention, n=33) received GI-targeted nutrition education through a web-based platform that was accessible only to HEALD-GI participants randomized to the intervention group. In addition to the web-based platform, the intervention group also received an evidence-based print material, "The Shopper's Guide to GI Values: The Authoritative Source of Glycemic Index Values for More Than 1,200 Foods" [192]. The web-based platform housed 6 self-directed learning modules over 12-weeks. Each module focused on a different aspect of GI education and included a video featuring a Registered Dietitian, links to reliable websites, asynchronous chat rooms, and module-content-related quizzes. The website was managed by a trained research assistant. The chat room discussions were moderated under the supervision of the co-investigators: KS, a researcher and Registered Dietitian and researchers, STJ and JAJ. Evidence-based GI content included GI values of foods, low-GI shopping, recipes, cooking tips and advice for eating out. Participants gained access to a new module every 2-weeks. Based on individual preference, additional support was provided through email, text message, phone calls, or mail to reinforce participants' learning. University of Alberta and Athabasca University Health Research Ethics Boards approved the study protocol and all participants provided written informed consent.

5.3.1 Assessment of Computer Proficiency of Participants

Participants' computer proficiency was measured at baseline, using the Computer Proficiency Questionnaire (CPQ), developed for evaluating the competencies of older adults regarding computer use and associated applications such as the internet [212]. The CPQ assesses competence across six dimensions: computer basics, printing, communication, Internet, scheduling software (calendar), and multimedia use (entertainment). The six subscales of the full (33-item) CPQ have 3–9 questions each while the shorter CPQ-12 versions has 2 questions per subscale. The general and specific competencies of participants in this study were assessed using the CPQ-12 plus three relevant items from the full (33-item) version. The CPQ-12 is a valid, easy to administer, and less time consuming version recommended for assessing general computer proficiency of older adults without having them demonstrate their skill. Participants were asked to rate their ability to perform a number of computer-related tasks (e.g., I can: Find information about local community resources on the Internet; I can: Use a computer to watch movies and videos) on a 5-point scale (*1 = Never tried, 2 = Not at all, 3 = Not very easily, 4 = Somewhat easily, 5 = Very easily*). Average responses to CPQ items were summed to produce subscale and total CPQ scores for gauging an individual's specific and overall computer proficiency and Cronbach's alpha (α) was determined to assess reliability [212].

5.3.2 Email, Website, Chat Room Use Among Intervention Group

Participants' preferred medium for receiving intervention-related alerts and reminders regarding new modules was assessed using a questionnaire. Email use was based on participants' access to the intervention website and module using links sent via email or direct email communication with the research team. Website and Internet chat room use were not assessed in the control group at baseline per the study design. However, given that randomization (theoretically) minimizes selection and allocation bias and makes groups comparable according to both known and unknown confounding factors, we would expect that the observed website and Internet chat room use is similar across both intervention and control group. Participant response to at least one quiz was used as a proxy for measuring HEALD-GI intervention website use. Intervention chat room use was based on a simple count of conversations displayed in the chat room over 12 weeks and was based on assigned participant study identifiers and expressed as proportions.

5.4.0 Statistical Analyses

Descriptive statistical analyses were completed for demographic and clinical data. Unadjusted and adjusted multiple linear regression analyses assessed the relationships between computer proficiency (dependent variable) and socio-demographic factors. Informed by outcomes of regression analyses, age was categorized as ≤ 65 and >65 years based on data inspection, Canada's retirement age in social institutions, and widely accepted definition of seniors [213]. Educational status was categorized as high school or below and college or higher. Two sample t-tests were used to compare mean differences between individual, subscale, and total CPQ scores by age and education. P values<0.05 were considered significant. All statistical analyses were performed using STATA (version 12.1,StataCorp, College Station, Texas, USA, 2012).

5.5.0 Results

5.5.1 Participant Characteristics and Missing Data

A total of 67 eligible adults responded to the invitations sent out to all ABCD Cohort [161] participants living in Edmonton (N=485) and were recruited to participate in the HEALD-GI trial. Participant recruitment, randomization, and retention have been described elsewhere [191] and summarized in (Figure 5.1). The control and intervention groups appeared to be similar on most characteristics at baseline (Table 5.1), although more people in the intervention group reported being retired. Participants were 64% men; mean age 69.5 (9.3) years, with mean diabetes duration of 19.0 (13.7) years, BMI 30.1 (5.7) kg/m^2, and HbA1c 7.1 (1.2)% at baseline (Table 5.1).

Participants, (n=67) were over-recruited to compensate for an estimated 30% attrition per arm [191]. Six participants (intervention=2, control=4) who did not provide baseline primary outcome data by returning 3-Day Food Records were excluded from all analyses thereby reducing the number of those included in the final analyses to 61 (intervention=31, control=30). For this cross-sectional study however, all participants (n=67) were included in the analysis.

5.5.2 Computer Proficiency of Participants

Overall, participants reported high total CPQ score (25.4 ± 4.9), indicating excellent computer proficiency and experience prior to beginning the intervention. Across CPQ subscales, participants reported the highest average scores for computer basics (4.9±0.3) and the lowest scores for entertainment (3.7 ± 1.6). Within the communication subscale, participants reported the highest average CPQ score for "opening emails" (4.9 ± 0.4) and "sending emails" (4.8 ± 0.5) but reported the lowest average CPQ score for "chat using Internet chat rooms" (3.1 ±1.8) (Tables 5.1 or 5.2).

The difference in total CPQ score, which is the measure of overall computer proficiency, was not obvious between the two education categories. However, those with college or higher education reported a higher score (4.1±14) for the entertainment subscale compared with those having high school or lower education (3.0±1.7) ($p<0.01$) (Table 5.2).

Total CPQ score for participants 65 years and below (27.9 ±4.0) was significantly higher than those above 65 years (24.6 ±5.0), ($p=0.01$). Across subscales, calendar use and entertainment among adults 65 years and younger were significantly higher than those above 65 years, ($p=0.01$) (Table 5.3).

5.5.3 Reliability of Computer Proficiency Measure

Cronbach's α was calculated to measure internal consistency (reliability) of the CPQ test items and subscales in capturing the computer proficiency of participants. Overall, the scale showed excellent reliability (Cronbach's $\alpha = 0.91$). Subscale reliabilities ranged from 0.89 to 0.91

(computer basics: 0.91, printing: 0.89, communication: 0.89, Internet: 0.89, calendar: 0.91, entertainment: 0.90).

5.5.4 Predictors of Computer Proficiency

In the unadjusted model, age, education, and employment status were associated with overall computer proficiency. In the adjusted model (Table 4), age and education were retained as independent predictors of computer proficiency in this population ($F (2, 65)=9.91$, $p < 0.001$, $R^2=0.24$)

5.5.5 Email, Website, Chat Room Use

Out of all participants randomized to the intervention group at baseline (n=33), 97% (n=32) chose email as their preferred medium for receiving alerts and reminders regarding when access to the next intervention module was available. All 33 (100%) communicated with the research team within the 12-week period via email. This aligns with data, which showed that 97% preferred email communications. Approximately 94% (31/33) logged in and used the intervention website to access at least one of the six modules during the study duration. The 6% (2/33) who did not log in to the intervention website were also lost to follow up. Slightly less than one-quarter (24%) of those who logged in to the intervention website engaged in the moderated chat room discussions, participating in an average of 2 chats. Those who did use the chat room were mean (SD) age 75.0 (3.9) years and did not differ from non-users by sex, age or education.

5.6.0 Discussion

We examined the computer proficiency of adults with T2D prior to participating in a lifestyle intervention focusing on diet. We found that, while participants had very high computer proficiency overall, age and education were predictors of computer proficiency, as measured by the CPQ. Being younger, i.e. 65 years or less, and having college or higher education was associated with higher computer proficiency. Understanding how, and if, this population of older adults with a chronic disease interact with technology is crucial for developing interventions according to their needs [212]. Furthermore, accounting for computer proficiency may help to explain variation(s) in the outcome(s) of interest when technology is used as the mode of delivering chronic disease management support. To the best of our knowledge, this is the first study to report the computer proficiency of older adults with T2D participating in a web-based self-management intervention.

Specific and total CPQ scores have been shown to be related to specific and general technology use and experience in another population [212]. High CPQ scores of participants in this study could therefore be used as a proxy for their ability to use computers and handheld mobile devices, including tablets and also smartphones with Internet connections, to actively access and use the various components of the web-based intervention.

Being able to make content-related exchanges, plan related tasks, and access social support are essential components of web-based learning environments known to engage participants, sustain online community, and improve learning [20, 214]. The current intervention relies on both customized and automated emails for communication between participants and the research team and web-based chat rooms for social support between participants [191]. Chat rooms in web-based learning environments have been shown to stimulate creation of relationships that enhance collaborative learning through shared experiences [20, 214]. Within the communication subscale, participants reported the highest average CPQ score for "opening emails" and "sending emails" but reported the lowest average CPQ score for "communicating using Internet chat rooms". These were confirmed by the patterns of actual use where 97% of participants randomized to the intervention requested email for reminders but all (100%) participants were able to send and open email communications about the study while less than one quarter contributed to chat room discussions. These outcomes have been echoed by others who have shown that older adults did not access Internet chat rooms because of trust; the need to type long and detailed responses, which they consider is not like real conversations; and the fact that they may be offended if they are not noticed in a chat room [211, 215]. The comparatively lower CPQ scores for the entertainment subscale is also consistent with previous findings [191] and is typical of this age group whose primary use of computers and Internet applications is for maintaining meaningful social relationships with family and friends, especially grandchildren [204, 216]. Interventions using web-based lifestyle interventions for chronic disease management among older adults may therefore need to consider their age, education, preferences, and if they have averseness to web-based chat rooms as demonstrated in this study.

Screening HEALD-GI participants' computer proficiency using a validated, quick and easy tool like the CPQ has significant merit for gauging participants' readiness, and highlighting any existing training needs that can influence uptake and effectiveness of the web-based intervention. It also improves precision and power for isolating the treatment effect on outcomes. Again, it helps eliminate wastefulness resulting from developing interventions that do not match the needs of the target population [191, 212]. The merits notwithstanding, interpretation and generalization of findings from this study should be done with caution. This study was limited to Edmonton, Alberta and a small sample of older English speaking adults, who were mainly Caucasian, well educated, and earned a mean annual income over $40,000. Secondly, this is the first study to document computer proficiency in this population. As such, the high computer proficiency observed could be suggestive of a potential bias of recruiting highly proficient participants, which limits generalizations about other adults with T2D. Finally, the small number of participants and lack of diversity in terms of ethnicity, language, socioeconomic factors, geographic location, and health status may also limit generalizability of findings regarding other potential predictors of computer proficiency in this population [211, 216, 217].

5.7.0 Conclusion and Recommendation

Participants demonstrated very high computer proficiency for effective uptake of the web-based HEALD-GI nutrition education intervention. Healthcare providers supporting this population can consider augmenting current care practices with appropriate web-based diabetes self-management education and support.

Table 5.1: Participant Characteristics

	All (n=67) (mean, SD) or (%)	**Intervention** (n=33) (mean, SD) or (%)	**Control** (n=34) (mean, SD) or (%)
Sex (Males) (%)	43 (64)	20 (61)	23 (68)
Age (years)	69.5 (9.3)	70.7 (9.0)	68.4 (9.6)
Marital status, no. (%)			
Married or common law	47 (70)	20 (61)	27 (79)
Not married (never married, widowed, divorced or refused to answer)	20 (30)	13 (39)	7 (21)
Ethnicity, no. (%)			
Caucasian	62 (93)	30 (91)	32 (94)
Non-Caucasian	5 (7)	3 (9)	2 (6)
Education, no. (%)			
High school and less	21 (31)	12 (9)	12 (35)
College and higher	46 (69)	24 (73)	22 (65)
Employment no. (%)			
Employed	10 (15)	2 (6)	8 (23)
Unemployed	5 (7)	1 (3)	4 (12)
Retired	52 (78)	30 (91)	22 (65)
Annual Household Income (CAD$)			
<$40,000	8 (12)	3 (9)	5 (15)
$40,000 – $79,999	30 (45)	16 (49)	14 (41)
≥$80,000	20 (30)	7 (21)	13 (38)
Do not know/refused to answer	9 (13)	7 (21)	2 (6)
Diabetes duration (years)	19.0 (13.7)	20.0 (11.7)	18.0 (15.5)
A1c (%)	7.1 (1.2)	7.0 (1.4)	7.1 (0.9)
Total cholesterol (mmol/L)	4.4 (1.0)	4.3 (1.0)	4.5 (0.9)
HDL (mmol/L)	1.3 (0.4)	1.4 (0.4)	1.3 (0.4)
TC/HDL Ratio	3.6 (1.5)	3.3 (0.9)	3.9 (1.9)
Systolic BP (mmHg)	127.9 (12.4)	127.7 (9.9)	128.2 (14.6)
Diastolic BP (mmHg)	70.1 (10.6)	69.8 (8.1)	70.5 (12.8)
Resting Heart Rate (bpm)	77.8 (14.5)	78.8 (15.3)	76.8 (13.9)
Body Mass Index (kg/m^2)	30.1 (5.7)	28.0 (5.1)	32.0 (5.6)
Waist Circumference (cm)	107.4 (16.1)	102.5 (15.5)	112.2 (15.4)

Table 5.2: Mean CPQ Score by Education

CPQ Subscales/ Composite Items	CPQ Score Mean ± SD All (N=67)	≤ High school (n=21)	≥ College/ University (n=46)	Difference	P-value
Total CPQ Score	**25.42 ± 4.92**	**23.99 ± 5.22**	**26.07 ± 4.69**	**-2.07**	**0.11**
1. Computer basics	**4.87 ± 0.32**	**4.90 ± 0.26**	**4.86 ± 0.34**	**0.05**	**0.57**
Use a computer keyboard to type	4.84 ± 0.41	4.86 ± 0.35	4.83 ± 0.44	0.03	0.78
Use a mouse	4.91 ± 0.29	4.95 ± 0.22	4.89 ± 0.31	0.06	0.42
2. Printer	**4.32 ± 1.28**	**4.12 ± 1.42**	**4.41 ± 1.21**	**- 0.29**	**0.39**
Load ink into the printer	4.33 ± 1.36	4.14 ± 1.49	4.41 ± 1.31	- 0.27	0.46
Fix the printer when paper jams	4.31 ± 1.31	4.10 ± 1.41	4.41 ± 1.26	- 0.32	0.36
3. Communication	**4.26 ± 0.70**	**4.06 ± 0.78**	**4.35 ± 0.66**	**- 0.28**	**0.13**
Open emails	4.88 ± 0.37	4.76 ± 0.54	4.93 ± 0.25	- 0.17	0.08
Send email	4.84 ± 0.48	4.67 ± 0.66	4.91 ± 0.35	- 0.25	0.05
Chat using Internet chat rooms∗	3.06 ± 1.76	2.76 ± 1.87	3.20 ± 1.71	- 0.43	0.35
4. Internet	**4.28 ± 0.98**	**3.93 ± 1.08**	**4.45 ± 0.90**	**- 0.52**	**0.05**
Find information about local community resources on the Internet	4.48 ± 0.88	4.14 ± 1.20	4.63 ± 0.64	- 0.49	0.03
Find information about my hobbies and interests on the Internet	4.63 ± 0.83	4.57 ± 0.93	4.65 ± 0.79	- 0.08	0.72
Bookmark websites to find them again later (e.g., make favorites)∗	4.15 ± 1.42	3.76 ± 1.64	4.33 ± 1.23	- 0.56	0.13
Save text and images I find on the Internet∗	3.88 ± 1.52	3.24 ± 1.81	4.17 ± 1.29	- 0.94	0.02
5. Calendar	**3.94 ± 1.54**	**4.00 ± 1.52**	**3.91 ± 1.56**	**0.09**	**0.83**
Use a computer to enter events and appointments into a calendar	3.85 ± 1.86	3.86 ± 1.68	3.85 ± 1.67	0.01	0.98
Check the date and time of upcoming and prior appointments	4.03 ± 1.56	4.14 ± 1.49	4.98 ± 1.60	0.16	0.69
6. Entertainment	**3.73 ± 1.56**	**2.98 ± 1.71**	**4.09 ± 1.37**	**- 1.11**	**0.01**
Use a computer to watch movies and videos	3.70 ± 1.64	3.10 ± 1.81	3.98 ± 1.50	- 0.88	0.04
Use a computer to listen to music	3.78 ± 1.68	2.86 ± 1.85	4.20 ± 1.42	- 1.34	<0.01

Data are means ± SD. Significance set at P< 0.05.
∗ Relevant items in full CPQ but not included in CPQ-12 (shorter version)

Table 5.3: Mean CPQ Score by Age

CPQ Subscales/ Composite Items	CPQ Score Mean ± SD All (N=67)	≤ 65 years (n=17)	> 65 years (n=46)	Difference	P-value
Total CPQ Score	**25.42 ± 4.92**	**27.93 ± 4.0**	**24.56 ± 4.95**	**3.36**	**0.01**
1. Computer basics	**4.87 ± 0.32**	**4.91 ± 0.36**	**4.86 ± 0.30**	**0.05**	**0.57**
Use a computer keyboard to type	4.84 ± 0.41	4.88 ± 0.49	4.82 ± 0.39	0.06	0.59
Use a mouse	4.91 ± 0.29	4.94 ± 0.24	4.90 ± 0.30	0.04	0.61
2. Printer	**4.32 ± 1.28**	**4.50 ± 1.32**	**4.26 ± 1.27**	**0.24**	**0.51**
Load ink into the printer	4.33 ± 1.36	4.53 ± 1.33	4.26 ± 1.38	0.27	0.49
Fix the printer when paper jams	4.31 ± 1.31	4.47 ± 1.33	4.26 ± 1.31	0.21	0.57
3. Communication	**4.26 ± 0.70**	**4.53 ± 0.69**	**4.17 ± 0.69**	**0.36**	**0.07**
Open emails	4.88 ± 0.37	4.94 ± 0.24	4.86 ± 0.40	0.08	0.44
Send email	4.84 ± 0.48	4.82 ± 0.53	4.84 ± 0.47	-0.02	**0.90**
Chat using Internet chat rooms∗	3.06 ± 1.76	3.82 ± 1.55	2.8 ± 1.76	1.02	0.04
4. Internet	**4.28 ± 0.98**	**4.66 ± 0.60**	**4.16 ± 1.06**	**0.51**	**0.07**
Find information about local community resources on the Internet	4.48 ± 0.88	4.53 ± 1.01	4.46 ± 0.84	0.07	0.78
Find information about my hobbies and interests on the Internet	4.63 ± 0.83	4.88 ± 0.33	4.54 ± 0.93	0.34	0.14
Bookmark websites to find them again later (e.g., make favorites)∗	4.15 ± 1.42	4.82 ± 0.53	3.92 ± 1.55	0.90	0.02
Save text and images I find on the Internet∗	3.88 ± 1.52	4.41± 1.12	3.70 ± 1.61	0.71	0.10
5. Calendar	**3.94 ± 1.54**	**4.76 ± 0.56**	**3.66 ± 1.66**	**1.10**	**<0.01**
Use a computer to enter events and appointments into a calendar	3.85 ± 1.86	4.71 ± 0.99	3.56 ± 1.75	1.15	0.01
Check the date and time of upcoming and prior appointments	4.03 ± 1.56	4.82 ± 0.53	3.76 ± 1.70	1.06	0.01
6. Entertainment	**3.73 ± 1.56**	**4.56 ± 1.06**	**3.46 ± 1.62**	**1.10**	**0.01**∗
Use a computer to watch movies and videos	3.70 ± 1.64	4.65 ± 1.00	3.38 ± 1.70	1.27	0.01
Use a computer to listen to music	3.78 ± 1.68	4.47 ± 1.33	3.54 ± 1.73	0.93	0.05

Data are means ± SD. Significance set at P< 0.05.
∗ Relevant items in full CPQ but not included in CPQ-12 (shorter version)

Table 5.4: Univariate and Multivariate Linear Regression Model Estimates (Coefficients, R^2, P-Values) Predicting Computer Proficiency

	Univariate			**Multivariate[1]**			**Multivariate[2]**		
	Coeff.	R^2	P-value	Coeff.	t	P-value	Coeff.	t	P-value
Sex	-0.25	<0.01	0.84	-	-	-	-	-	-
Ethnicity	-0.65	<0.01	0.78	-	-	-	-	-	-
Income	-0.58	0.02	0.23	-	-	-	-	-	-
Employment status	-2.38	0.13	<0.01	-1.43	-1.73	0.09	-	-	-
Age	-0.18	0.12	<0.01	-0.16	-2.42	0.02	-0.22[3]	-3.71	<0.01
Education	1.87	0.07	0.03	2.29	3.00	<0.01	2.39[4]	3.09	<0.01

Significance set at $P < 0.05$;
[1] Multivariate for age, education and employment status $R^2 = 0.27$ at $p<0.001$;
[2] Multivariate for age and Education $R^2 = 0.24$ at $p<0.001$
[3] Standardized β for age= -0.41
[4] Standardized β for education = 0.34

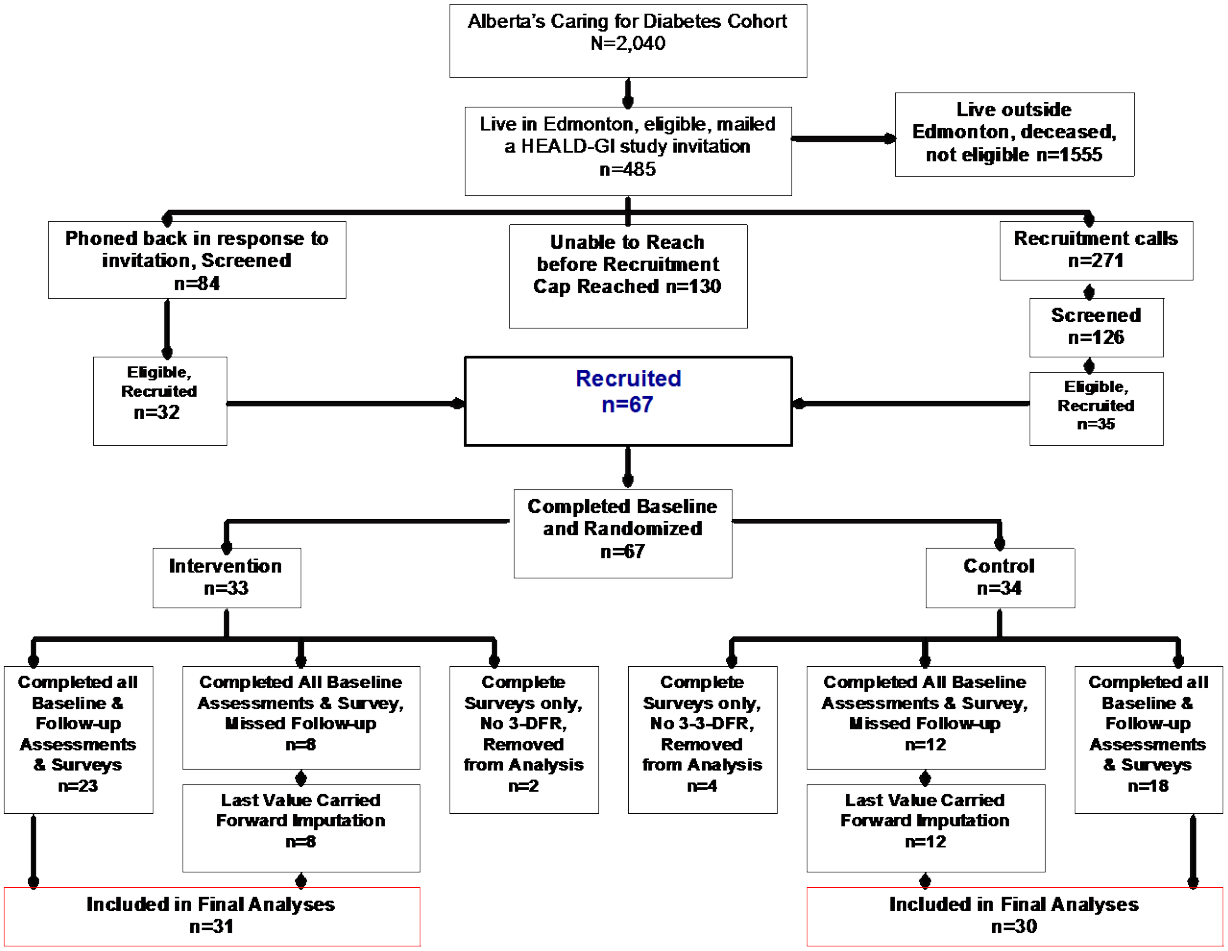

Figure 5.1: Flow diagram of participant recruitment, treatment allocation, and retention

CHAPTER 6

Summary and Conclusions

6.1.0 Introduction

Lifestyle, specifically healthy eating and physical activity, are crucial for the prevention and management of T2D. Given the available evidence supporting the importance of lifestyle modification for improved diabetes outcomes, guideline recommendations for diabetes management around the world focus on supporting patients to adopt healthy eating and physical activity as integral aspects of their daily self-management activities [2, 4]. However, it is important to assess and address knowledge gaps in the adoption of these recommendations and to model the best, practical approaches for incorporating them into daily self-management behaviours of people with T2D for optimal health outcomes. This demands the design and evaluation of novel, cost effective, and real-world lifestyle interventions that enhance uptake among people living with diabetes.

Metabolic control, involving reduction of hyperglycemia, prevention of hypoglycemia in individuals on insulin-treatment, and reduction of the risk of complications, especially cardiovascular disease, remains the central goal of diabetes management. The best evidence supporting the importance of dietary modification for diabetes management is generated from studies involving highly controlled participants and research environment. However, patients often find it difficult to adhere to these guidelines. Existing knowledge translation gaps further complicate uptake of guideline recommendations.

Research included in this thesis is aimed at providing an alternative approach for translating important guideline recommendations to support patients' dietary self-management practices. To achieve this, participants were provided with simple actionable messages regarding the GI concept within an overall healthy eating framework driven by existing knowledge gaps. The effectiveness of this dietary lifestyle modification was then evaluated using available tools to gain a better understanding of the factors influencing its adoption. Findings from this research are therefore important in that, they showcase existing gaps associated with the translation of specific Diabetes Canada's Clinical Practice Guideline dietary recommendation to substitute high GI foods with low-GI option. This research also provides an alternative, feasible and practical approach to translating available GI concept information to enhance uptake among people with diabetes. Findings from this work is also very useful for informing healthcare professionals supporting people with diabetes, particularly Registered Dietitians, to alternative cost effective and widely accessible strategies that complement their efforts at facilitating healthy dietary habits among patients.

6.2.0 Study Conclusions

Study 1: Capturing self-care dietary practices using the SDSCA and quantifying dietary intakes with a FFQ can be considered valuable approaches for healthcare providers supporting people with type-2 diabetes. The low-GI item included in this study may serve as a quick self-report measure of low-GI dietary behaviour and possibly serve as a marker of a better overall dietary intake.

Study 2: Sex differences exist in low-GI diabetes self-care dietary behaviours among men and women with T2D. Given that low-GI is a marker of carbohydrate and overall diet quality, simply improving GI-concept knowledge may be a valuable first step for improving a lower mean daily GI intake. Furthering our understanding of how and why men and women behave differently can serve to inform development of gender-sensitive approaches for enhancing diabetes self-care dietary practices among people living with T2D.

Study 3: The GI concept may be beneficial for improving health outcomes of people with diabetes. However, lifestyle behaviours are hard to change, especially in participants who are already consuming a low-GI diet and thus have very little room for change. Therefore, the significant reduction in mean daily GI intake observed, in addition to improvement in potential mediators, (i.e. knowledge, self-efficacy, intention), suggests that this web-based intervention has promise for overcoming GI-related and other dietary knowledge translation gaps. Future studies involving larger, more diverse sample may therefore be needed to expand on the feasibility and usefulness of this intervention in other populations.

Study 4: Participants demonstrated very high computer proficiency and hence this supported the uptake of the web-based HEALD-GI nutrition education intervention. Healthcare providers supporting this population can consider augmenting current care practices with appropriate web-based diabetes self-management education and support if the computer proficiency is known.

6.3.0 Summary

The importance of choosing low glycemic index foods as part of an overall healthy diet has been integrated into Clinical Practice Guidelines and research of major diabetes organizations including Diabetes Australia, Diabetes UK, the European Association for the Study of Diabetes, Diabetes Canada and recently, the American Diabetes Association. This simple message may help to improve carbohydrate and overall diet quality for people with diabetes leading to short -term metabolic control and improved long-term health outcomes. This thesis has shown the importance of capturing low-GI dietary behaviour of people with T2D using a simple tool as a marker carbohydrate and overall diet quality. This is helpful for the informing the healthcare professional regarding patients' current state as it relates to the GI concept. Showing existing sex differences in low-GI diabetes self-care dietary behaviours among people with T2D has also enhanced our understanding of health behaviours; knowledge can serve to inform development of gender-sensitive approaches for enhancing diabetes self-care dietary practices.

This research has also shown that older adults with T2D are highly computer proficient and can benefit from web-based nutrition education intervention. This knowledge is helpful for explaining outcomes of the web-based nutrition intervention but it is also informative for guiding effective implementation of future web-based interventions that augment current care practices.

Findings from this work have also shown that delivering simple messages around the GI concept using a bundle of patient preferred resources could yield a moderate effect and influence behaviour in the desired direction, even among participants who have fairly well controlled outcomes. This is very important because it shows that patients are willing to learn and take up guideline recommendations that help them best achieve optimal health if they are delivered using approaches that resonate with them.

6.4.0 Future Research

This research has demonstrated that it is possible to influence self-management dietary behaviours by delivering simple actionable messages that increase knowledge and clarify existing misconceptions regarding the GI concept using a bundle of patient preferred delivery modes and tools. Future research using this approach are highly recommended and suggestions for building on the current research are provided as follows:

(1) Given that this alternative approach of delivering simple messages around the GI concept using a bundle of patient preferred resources could yield a moderate effect and influence behaviour in the desired direction among participants with fairly well controlled outcomes, additional research may be needed to inform integration of this broad-reach intervention delivery approaches within clinical care and support for people with diabetes.

(2) Given the high computer proficiency observed in this small highly proactive but less ethnically and socioeconomically diverse participants, a larger study with more diverse participants may be needed to elucidate additional factors that may influence the computer proficiency of the general population of people with diabetes. Findings from such research can help develop appropriate web-based diabetes self-management education and support that supplement current care practices.

(3) Given the limited funding and duration of this pragmatic clinical trial to evaluate the effectiveness of GI-targeted nutrition education on dietary behaviour, participant recruitment was limited to the Alberta's Caring for Diabetes cohort participants residing in Edmonton. This limited the reach of the intervention, diversity in the sample as well as generalizability of findings. Given that behaviour modification is complex, especially in participants who had very little room for change, future programs that build on this work need to sample a larger, more diverse population for better external validity. Further, future research may need to be carried out over a longer period and include traditional face-to-face dietitian interactions for comparison to determine the true effect of this approach.

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APPENDIX

Healthy Eating and Active Living for Diabetes-Glycemic Index (HEALD-GI): Protocol for a Pragmatic Randomized Controlled Trial

A1.1.0 Abstract

Introduction: Rigorous evidence is needed regarding the best approach for increasing uptake of Diabetes Canada's evidence-based recommendations to include low glycemic index (GI) foods in daily meal planning as an effective dietary self-care strategy for glycemic control among people with type 2 diabetes (T2D).

Objective: To present the study design and baseline data from the Healthy Eating and Active Living for Diabetes-Glycemic Index (HEALD-GI), which is designed to evaluate the effectiveness of a web-based GI-targeted nutrition education on GI-related knowledge and intakes among adults with T2D in Edmonton, Alberta.

Methods: Participants (N=67) were randomized to a control group that received standard printed copies of Canada's Food Guide and Diabetes Canada's GI resources OR to an intervention group that received those same materials, plus a customized online platform with six self-directed learning modules and print material. Each module included videos, links to reliable websites, chat rooms, and quizzes. Evidence-based GI concept information included GI values of foods and low-GI shopping, recipes, and cooking tips by a Registered Dietitian. Support through email, text messaging, phone calls, or postal mail to reinforce participants' learning were also provided. The primary outcome, average dietary GI, was assessed using 3-day food records. Additional measures including GI knowledge and self-efficacy, glycated hemoglobin A1c, lipids, systolic blood pressure, body-mass-index (weight, height), waist circumference, and computer proficiency were assessed at baseline and at three months post-intervention.

Results: Participants were 64% men; mean age 69.5 (9.3) years, with mean diabetes duration of 19.7 (14.4) years, BMI 29.9 (5.8) kg/m^2, and HbA1c 7.1 (1.2)%.

Conclusion: The GI concept is often difficult to teach. The HEALD-GI study aims to provide evidence regarding the best approach to translating the GI concept to adults with T2D. Findings from this study may help Registered Dietitians to better disseminate low-GI dietary recommendations using efficient and cost-effective patient-centered approaches. Evidence generated will also contribute to addressing some of the controversies regarding the clinical usefulness of the GI concept.

ClinicalTrials.gov Identifier: *NCT03037099*

Keywords: Type 2 diabetes, glycemic index, randomized control trial.

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A1.2.0 Introduction

Increasing prevalence of type-2 diabetes mellitus (T2D) remains a major public health challenge with adverse effects for individuals and health care systems globally. Currently, diabetes affects approximately 7.3% of Canadians and prevalence has been projected to rise to about 10% by 2020 [25]. Health outcomes for individuals with diabetes, however, largely depend on their ability to self-manage the disease. Lifestyle interventions including healthy eating, physical activity, and smoking cessation that enhance acquisition of knowledge, skills, resources and support to boost self-efficacy for day-to-day living are therefore important for T2D management and prevention of long-term complications [218, 219].

Healthy eating remains a key strategy for diabetes self-management and dietary carbohydrates constitute one aspect of the diet with significant influence on blood glucose control. Different types and quantities of carbohydrates have been shown to impact blood glucose concentration differently [11, 115]. This property of foods, referred to as glycemic index (GI), is used to rank how quickly a given dietary carbohydrate raises blood glucose concentration immediately following a meal [11]. Using GI and the portion size of a given food, glycemic load (GL), a composite measure of carbohydrate quality and quantity, can be calculated to predict blood glucose response to a specific type and amount of a dietary carbohydrate [220]. Consuming low-GI foods is beneficial for metabolic control in diabetes management [221]. Adopting a low-GI dietary pattern as part of a healthy eating lifestyle has been shown to significantly improve glycemic control, cardiovascular risk factors (e.g. total cholesterol, HDL), postprandial glycemia, beta cell function and decrease need for anti-hyperglycemic agents among individuals with diabetes [39, 40, 103-111]. Outlining effective approaches to promote the concept of low-GI among individuals with T2D has been problematic. Hence, examining effective modes of delivery are necessary to support one aspect of T2D.

Effective and widespread use of information technologies (IT), including Internet and mobile-based tools, is revolutionizing traditional approaches for engaging, educating, and empowering individuals with chronic diseases such as diabetes [200, 201]. Increasing use of IT by diverse audiences, occasioned by low-cost web and mobile-based tools may therefore offer viable prospects for promoting swift and cost effective GI concept education and support among people with T2D. Features of modern IT tools such as websites, chat rooms, social networking sites (e.g. Facebook), and mobile phone text messaging applications allow creation and exchange of health promoting information and enable individuals to interact with other users who share connections with them [204, 205]. Properly designed and managed websites can serve as credible sources of evidence-based GI-targeted messages. Websites enable integration and presentation of text, graphics, or audio-visuals in one platform while chat rooms and emails facilitate engagement between users and health professionals in addressing pertinent issues [222]. Also, chat rooms provide online social forums for peer group discussions, exchange of ideas, encouragement, and support [14, 223].

Knowledge gaps exist between GI-concept clinical guidelines and their translation to adults with T2D in Canada due to debates over clinical utility of GI, inconsistencies in teaching the GI concept by registered dietitians [18, 19], and limited patient-dietitian interactions [15]. These limit patients' knowledge and skills for uptake of GI dietary behaviour. As such, patients lose out on the additional benefits of improving carbohydrate quality by consuming healthy low-GI foods as part of healthy eating strategy for diabetes self-management. Hence the aim of the current study is to examine the effectiveness of web-based GI-targeted nutrition education on dietary behaviour and intakes among adults with T2D. We hypothesize that after three months, adults with T2D who were randomized to receive web-based GI-targeted nutrition education will consume a lower GI diet and show improved glycemic control compared to a control group. Findings from this study will help determine if, and how, current approaches to disseminating dietary recommendations pertaining to GI concept could be improved for better uptake using alternative, efficient, and cost effective patient-centered approaches to nutrition self-care. Outcomes of this study will also add to the body of evidence regarding the GI concept.

A1.3.0 Methods

A1.3.1 Summary Study Design

Adults (≥18 years) living in Alberta with T2D and currently enrolled in the Alberta Caring for Diabetes (ABCD) Cohort [161] study constituted the target population for this study. Using a pragmatic randomized trial design, 67 eligible participants drawn from the ABCD cohort [161] were randomized into two groups, (i.e. usual care and enhanced GI-targeted learning). Group 1 (control, n=34) received standard printed copies of Canada's Food Guide and Diabetes Canada (formerly Canadian Diabetes Association) GI resources. Group 2 (intervention, n=33) received additional 12-week GI-targeted nutrition education through a web-based platform with 6 self-directed learning modules, print material, and additional individualized support. Each module included customized videos featuring a Registered Dietitian, links to reliable websites, chat rooms for social support, and quizzes. Evidence-based GI content included GI values of foods, low-GI shopping, recipes, cooking tips, and advice for eating out. Participants received a new module every 2 weeks. Based on individual preference, additional support was provided through email, text message, phone calls, or mail to reinforce participants' learning. Our primary outcome measure is GI related dietary behaviour change and intake, measured using a 3-day food record. Other measures, including GI knowledge and skill, self-efficacy, body mass index (weight and height), waist circumference, clinical measures (glycated hemoglobin A1c, systolic blood pressure, total cholesterol, HDL), and computer proficiency were assessed at baseline and three months post-intervention. The University of Alberta and Athabasca University Health Research Ethics Boards reviewed and approval the study protocol and all participants provided written informed consent.

A1.3.2 Sampling Strategies, Recruitment Plans, Ethical Considerations

Setting and Population: Eligible individuals were drawn from the ongoing ABCD cohort study, which was designed to explore different aspects of diabetes care and the development of complications among individuals with T2D in Alberta. The ABCD cohort enrolled 2040 participants between 2012 and 2013 from all over the province of Alberta at its inception and provided a suitable eligible population from which to draw participants for this intervention. Characteristics of the ABCD cohort have been published elsewhere [161].

Inclusion and Exclusion Criteria: Individuals 18 years of age or older identified as having T2D and currently enrolled in the ABCD cohort study; able to read, understand, and converse in English; and willing to provide informed consent were eligible to participate in the study. For practical considerations, all cohort participants living in Edmonton were pre-screened for enrolment in the intervention. Based on postal codes, 745 cohort participants who participated in the year one ABCD survey lived in Edmonton. However, due to relocation and mortality-related attrition, only 485 ABCD cohort participants living in Edmonton between July 2017 and July

2018 were contacted to determine eligibility and for subsequent recruitment into the study. Those taking exogenous insulin and having physiological and/or medical conditions that interfere with usual digestive functions were excluded.

Participants Screening Procedures: Letters explaining details of the study were sent to all eligible participants asking them to contact the study staff if they were interested in participating in this study. Detailed pre-screening was carried out over the phone to determine full eligibility once we received responses from those invited to participate. A maximum of two telephone contacts were made to remind eligible individuals who did not contact research staff after two weeks of expressing their interest in participating in the study. Eligible participants were invited to complete baseline anthropometry, biochemical, clinical, and dietary data collection at the Human Nutrition Research Unit located within the Alberta Diabetes Institute at the University of Alberta. A trained Registered Dietitian and Registered Nurse with data collection experience collected anthropometric data and relevant clinical measures using point-of-care instruments (DCA Vantage, Cholestech LDX, and BPTru).

Ethical Considerations: The University of Alberta and Athabasca University Health Research Ethics Boards reviewed and approval the study protocol. In line with research ethics requirements, all participants received adequate information about the study and had the opportunity to ask questions. Written informed consent was obtained from participants prior to obtaining any study measurements after they received an explanation of: 1) the purpose of the study; 2) the allocation process; 3) the use of data and the means of assuring confidentiality; 4) voluntarily participation and the participant’s right to withdraw from the study at any time; and 5) any potential harm that could occur as a result of the intervention.

A1.3.3 Randomization and Treatment Allocation

Using a simple randomization approach [224], participants (N=67) who provided informed consent and completed baseline anthropometry, clinical, and dietary measurements were randomly assigned to either the usual care or to intervention in a 1:1 ratio using a computer-generated allocation sequence (Stata SE 12.1; StataCorp, College Station, Texas, USA). Allocation sequence and group assignments were generated centrally and enclosed in sequentially numbered and sealed envelopes. A statistician not involved with other aspects of the trial conducted all randomization-related procedures.

Usual Care: Study participants allocated to the usual care (control arm) received standard printed copies of Canada's Food Guide and Diabetes Canada GI resources in line with current Diabetes Canada Clinical Practice Guidelines [6, 86]. The control group did not receive extra support aimed at increasing knowledge or skills for daily consumption of low-GI foods.

Enhanced GI-Targeted Nutrition Education: The GI concept and content of this intervention were in-line with current Diabetes Canada Clinical Practice Guidelines as well as T2D patients' suggested content and preferred modes of learning GI information [14, 39]. Participants allocated to the enhanced low-GI education intervention group received the same information as the control group in addition to vetted, evidence-based, learner-centered, low-cost, and actionable low-GI messages via a professionally designed GI-targeted education website with chat rooms, customized videos featuring an RD, and print material. These were reinforced through email, mobile phone text messaging, phone call or postal mail based on participant preferences and needs. The website was managed by trained research assistant who also moderated chat room discussions under the supervision of the co-investigators: KS, a Registered Dietitian and researcher, STJ, and JAJ who also possess extensive research experience.

Participants received brief tutorials on website login, navigation, and usage during baseline data collection, which was reinforced at first login with a short video introduction to the program. The video emphasized the importance of low-GI eating and summarized the various aspects of the intervention. Participants allocated to the intervention group covered a total of 6 modules aimed at enhancing knowledge and skill for improved GI dietary behaviour change over a period of 12 weeks with each module lasting for 2 weeks. Specific topics covered in these modules included 1) general healthy eating for diabetes, 2) summary of GI concept, 3) identifying, choosing and shopping low-GI, 4) low-GI recipes, menus and meal planning, 5) guidelines for eating out and snacking, and 6) GI concept and general diabetes self-management and healthy lifestyles. Participants were encouraged to outline and track personal, easily achievable goals that could enhance their GI knowledge and skill under each module. For example, in module 3, a participant could set a simple goal to learn how to identify low-GI versions of foods that he or she usually consumed. Each module was delivered via the intervention website using interactive user-friendly text, graphical displays, and module summary videos. Short, module-specific customized videos were developed in line with Canada's Food Guide and Diabetes Canada Nutrition Therapy Clinical Practice Guidelines-based GI recommendations [6, 86] to teach participants "hands-on" application of GI to daily meal planning.

To maintain their enthusiasm, participants were granted access to subsequent modules at the end of the preceding module on the first day of each 2 week cycle. This was accompanied with electronic reminders delivered via email or mobile phone text message based on participants' choosing. Participants responded to short quizzes meant to bolster key GI principles and lessons learned. Chat rooms were activated for each module to enable participants to share experiences in the form of success stories, challenges, and tips that enhance a sense of community for social support among participants. The chat room forum was monitored and timely responses were provided to questions and concerns of participants. In addition, web links to the international tables of GI and GL values of foods [165], additional evidence-based information on GI concept and general diabetes self-management and healthy lifestyles were provided. A review of similar web-based studies has shown that interventions that provide interactive elements such as 1) quizzes, searchable database, audio/video; 2) counsellor support through counsellor-led chat sessions, email or phone contacts; 3) peer support through online discussion forums or chats; and 4) regular updates of information on intervention websites have been effective at generating and sustaining participants' interest and exposure to web-based interventions [225].

Participants in the enhanced GI-education arm also received copies of 'The Shopper's Guide to GI Values: the Authoritative Source of Glycemic Index Values for More Than 1,200 Foods' [192] in line with T2D patients' preference for print-based material as a source GI information [14]. Briefly, the Shopper's Guide, which was recommended to participants seeking to know more about GI in a previous study [226], is a lightweight handy book co-authored by expert GI research scientists. It contains glycemic index values of over 1,200 foods arranged by categories to help identify healthier low-GI carbohydrate alternatives using handy household measures. The Shopper's Guide is updated regularly and has comprehensive data on carbohydrates per serving and glycemic load, a shopping list of low-GI essentials, ideas for gluten-free meals, facts about sugar and sweeteners, and tips for everyday meals and dining out. The Shopper's Guide also provides links to supplementary resources with reliable, evidence-based GI information [192].

In addition to the website and the Shoppers Guide [192], participants in the intervention arm were also offered periodic e-mails, text messages/telephone calls or postal mail prompts to visit the website and/or use the print materials to acquire more GI knowledge as per individual preference. Participants were encouraged to use these mediums to seek assistance regarding specific personal dietary issues which they may not want to post in the chat room discussion section of the website.

A1.3.4 Assessment of Study Outcomes

A1.3.4.1 Socio-Demographic and Clinical Covariates

Demographic information including age, sex, marital status, education, employment status, income, and personal history of CVD risk factors (i.e., smoking, height, weight, BMI), and time since T2D diagnosis were collected at baseline and after 3 months. Self-reported physical activity was assessed using the Godin Leisure Time Exercise Questionnaire (GLTEQ) [227] modified to calculate metabolic equivalent of task (MET) minutes for total moderate and vigorous physical activity.

A1.3.4.2 Computer Proficiency

Participants' computer proficiency was measured using the Computer Proficiency Questionnaire (CPQ) at baseline and 3 months post intervention. The CPQ was developed for evaluating the competencies of seniors with regards to use of computers and associated applications such as the internet [212]. The CPQ assesses competence across six different subscales: computer basics, printing, communication, Internet, scheduling software (calendar), and multimedia use (entertainment) for gauging an individual's specific and overall computer proficiency.

A1.3.4.3 Dietary Assessment

Daily dietary intake was assessed for all participants at baseline and at 3 months using a 3-day food record. Three-day food records are valid and reliable for capturing dietary behaviour change by asking participants to record their food consumption as they eat [130]. All participants were asked to record, in as much detail as possible, descriptions of foods and beverages consumed over a 3-day period (i.e. 2 week days and 1 weekend day). Participants were given further instructions on how to fill out the 3-day food record. Colour photographs were provided to assist participants with estimating and recording appropriate portion sizes of foods and beverages they consumed in the 3-day food record logbooks. Pictures showing sample portions sizes of foods measured against items including a finger, palm of a hand, and a hockey puck were included and participants were encouraged to choose photographs that best represented their portion sizes or specify if they consumed more or less. Mean daily food consumption and nutrient intakes were estimated using the Food Processor Diet Analysis and Fitness Software (ESHA Research, Salem, USA) at baseline and 3 months using the Canadian nutrient file. Daily average GI and glycemic load (GL) were calculated for all carbohydrate-containing foods identified from the 3-day food record using published international GI tables [151, 165].

A1.3.4.4 Clinical and Anthropometric Measures

Clinical outcome measures included A1c, SBP and lipid profile. Capillary blood samples (35μL) were collected from participants to assess A1c using previously validated point-of-care testing device for A1c (DCA Vantage) [228] and lipid profile (Cholestech LDX). Systolic blood pressure was measured according to standard protocols using (BPTru) [229].

Weight, height, and waist circumference were also assessed according to the Canadian Physical Activity, Fitness and Lifestyle Appraisal procedures [230]. Body weight in kilograms and height in meters were measured for each subject with light clothing and no shoes. Body weight was measured to the nearest 0.1 kg with a portable digital scale (Tanita BWB-800S, Arlington Heights, IL). Height was measured using a portable stadiometer (Tanita HR-100). Waist circumference was measured to 1 mm at the top of the iliac crest using a spring-loaded Gulick anthropometric tape (FitSystems Inc., Calgary, AB). Regular, monthly quality assurance checks were conducted on the point-of-care devices and scale.

A1.3.4.5 GI Knowledge and Self-Efficacy Assessment

Pre- and post-intervention GI concept knowledge, and self-efficacy were assessed and quantified using the Glycemic Index Foods Quiz (GIFQ) from a previous study [180]. Dietary data from a previous intervention within the same population showed that, out of 196 participants, 16% were not familiar with low-GI eating and 28% did not include low-GI foods in their diets [16]. About 70 (35%) out of 199 indicated that they did not know about GI and of those who claimed knowledge of GI; only 34% reported choosing low-GI foods for more than 6 months in another study [231]. These corroborate previous findings in which only 38% of people with diabetes received nutrition therapy across Canada [15] with less than 40% of dietitians including GI concept in T2D dietary self-care counseling [18, 19]. Overall dietary self-care behaviour was assessed using dietary items in the validated and widely used Summary of Diabetes Self-care Activities (SDSCA) measure [145]. The GIFQ therefore enabled assessment of the net change in GI knowledge and self-efficacy due to the intervention.

A1.3.4.6 Intervention Preference and Website Usage Data

Preference and usefulness of the web-based, print [192], email, SMS/telephone call, and postal mail were assessed by asking participants how many times they visited the web-page, read and made references to Shopper's Guide [192], and how much time they spent on the website or reading the book. Participants were also asked which medium they found most helpful and if the information about GI concept was informative, and helped to increase their knowledge and self-efficacy for consuming low-GI foods. Website data measurement programs were built into the website design to compile data points as connections occur with the target audience [232]. Regularly collecting, tracking, and using measurement data makes it possible to understand participants' characteristics and helps to keep the intervention appealing and relevant for achieving the greatest effect [232].

A1.4.0 Statistical Analysis, Power and Sample Size Rationale

A1.4.1 Statistical Analysis

Change in mean daily GI of dietary carbohydrates from baseline to 3 months will be used as our primary effectiveness measure for improved low-GI knowledge and application. Descriptive statistics will be computed for all variables to determine the nature of the data and to test for normality assumptions. Chi-square and t-tests will be used to compare baseline participant characteristics between usual care and enhanced GI learning conditions and to test for treatment group differences in baseline dietary behaviour. Changes in outcomes will be assessed by repeated-measures two-way ANCOVA. Potential socio-demographic and clinical factors associated with enhanced GI learning will be evaluated using generalized linear mixed-model analysis (GLMM). Treatment condition, baseline scores, participant characteristics (e.g. sex, education, and income) and computer proficiency that may be significantly related to outcomes will be controlled for. All data will be analyzed using Stata SE 12.1, StataCorp, College Station, Texas, USA.

A1.4.2 Power and Sample Size Rationale

Based on previous studies regarding the efficacy of GI-based nutritional education and glycemic control [109, 180] and meta-analysis of studies on low-GI diets and diabetes management [103], an estimated effect size of d=1 was set for this intervention. Previous data [16] suggest a standard deviation of GI intake of 4 to 5 units; thus an effect size d=1 could be achieved with an absolute mean difference of 5 units of GI intake. Given the estimated effect size, 42 participants (21 per arm) was sufficient for detecting an absolute mean difference of 5 units on the GI intake scale between means with an error of $\alpha = 0.05$ (two-sided) and $\beta = 0.1$ (power $1 - \beta = 0.90$) (Table A1.2). This difference is considered to have significant health benefits from a previous study in which a change of 15 GI units yielded a corresponding A1c change of -1.5% [180] and another study in which 4.6 GI units change yielded A1c change of -0.25 (95% CI -0.50 to -0.004) [109]. With an estimated attrition rate of 30% (based on ABCD cohort year two participation rate), eligible participants were oversampled (N=67) during recruitment to account for possible loss to follow-up during randomization and intervention periods. This sample size was feasible in view of the dietary assessment (3-day food record) method employed to assess food intakes and change in dietary GI, the cost of biochemical and clinical measurements as well as the duration of the study.

A1.5.0 Results

A1.5.1 Summary of Progress to Date

Intervention milestones including ethics application, hiring and training of research assistants, development and pilot testing of intervention materials ran from July 2016 to October 2017.

A1.5.2 Recruitment, Enrolment Status and Timelines

Recruitment and enrolment in the HEALD-GI trial ran from November 2017 to February 2018. The flow diagram showing details of the recruitment, screening, random allocation, and baseline and follow-up data collection are summarized in Figure A1.1. Baseline and three months follow-up data collection were completed in June 2018. Currently, the study database is being compiled in preparation for carrying out appropriate analyses and dissemination of findings.

A1.5.3 Participant Characteristics

Participants are 64% men; mean age 69.5 (9.3) years, with a mean diabetes duration of 19.7 (14.4) years, BMI 29.9 (5.8) kg/m^2, and A1c 7.1 (1.2)% (Table A1.1).

A1.6.0 Discussion

This protocol outlines the study rationale, design, and evaluation of the Healthy Eating and Active Living for Diabetes-Glycemic Index pragmatic randomized controlled trial and reports the baseline characteristics of 67 individuals living with T2D in Edmonton, Alberta Canada. The HEALD-GI trial was designed to evaluate the effectiveness of a web-based GI-targeted nutrition education on GI-related knowledge and intakes among adults with T2D.

Major strengths of this trial include the evidence-informed components of the web-based enhanced GI-targeted nutrition education including internet chat rooms for peer support, use of email, SMS and telephone support, which have been shown to enhance intervention uptake and effectiveness [225, 233]. Emails, text messages and telephone support enable educational content-related exchanges while chat room platforms in online learning environments enhance social support through creation of relationships that support collaborative learning and sharing of relevant experiences [20, 214, 234]. The involvement of a health professional as a moderator of the web-environment has also been shown to enhance online intervention outcomes [233, 235]. The provision of 'The Shopper's Guide to GI Values: the Authoritative Source of Glycemic Index Values for More Than 1,200 Foods' [192] also supports preferences for print-based material as a source GI information [14]. This may enhance participant knowledge and self-efficacy for low-GI concept uptake. Use of a 3 day food record method for dietary intake data will help to curb recall bias which is often associated with memory dependent dietary assessment methods such as 24-hr recall [130].

A1.7.0 Conclusion

The GI concept is often difficult to teach. The HEALD-GI study aims to provide evidence about the best approaches for translating the concept to adults with T2D. Findings from this study may help Registered Dietitians to better disseminate low-GI dietary recommendations using the efficient and cost-effective patient-centered approaches. Evidence generated will also contribute to addressing some of the controversies regarding debates surrounding the clinical usefulness of the GI concept.

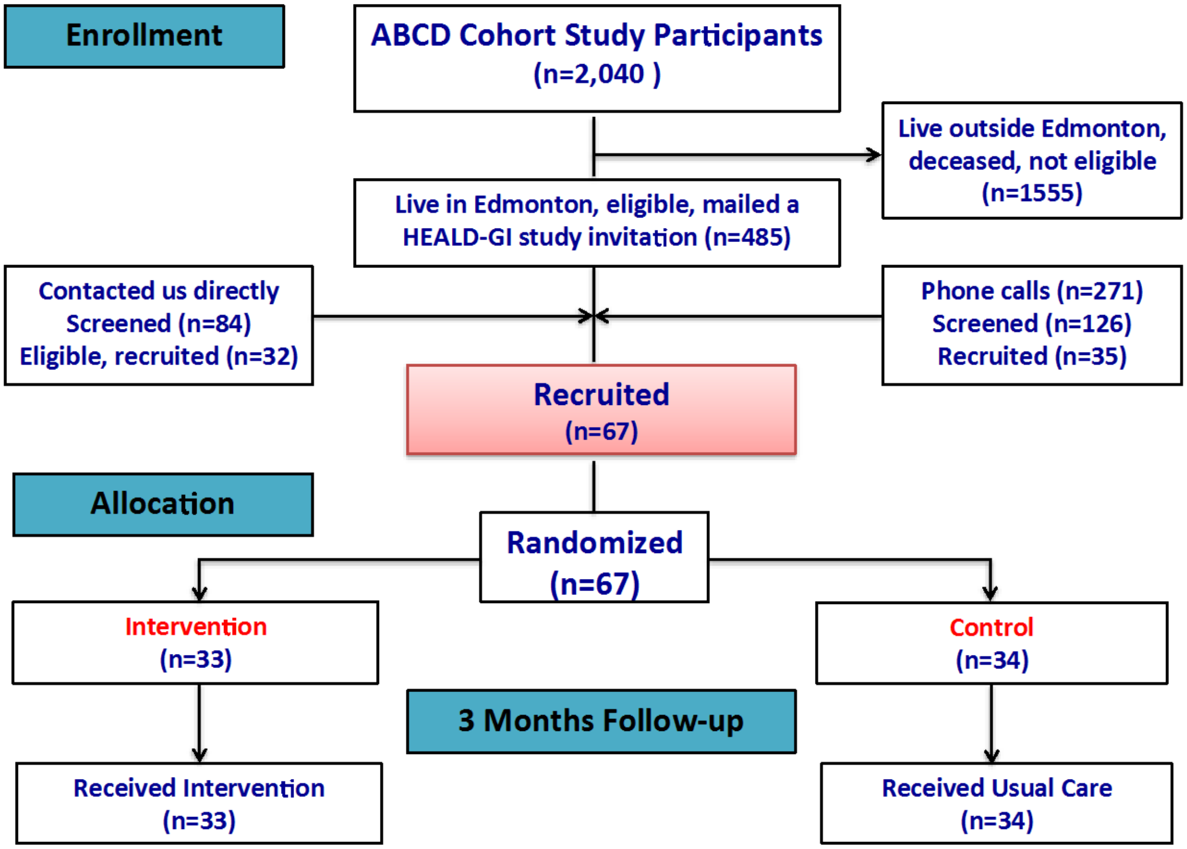

Figure A1.1: Flow diagram showing participant recruitment and treatment allocation

Table A1.1: Participant Characteristics

	All (n=67) (mean, SD) or (%)	**Intervention** (n=33) (mean, SD) or (%)	**Control** (n=34) (mean, SD) or (%)
Sex (Males) (%)	43 (64)	20 (61)	23 (68)
Age (years)	69.5 (9.3)	70.7 (9.0)	68.4 (9.6)
Marital status, no. (%)			
Married or common law	47 (70)	20 (61)	27 (79)
Not married (never married, widowed, divorced or refused to answer)	20 (30)	13 (39)	7 (21)
Ethnicity, no. (%)			
Caucasian	62 (93)	30 (91)	32 (94)
Non-Caucasian	5 (7)	3 (9)	2 (6)
Education, no. (%)			
High school and less	21 (31)	12 (9)	12 (35)
College and higher	46 (69)	24 (73)	22 (65)
Employment no. (%)			
Employed	10 (15)	2 (6)	8 (23)
Unemployed	5 (7)	1 (3)	4 (12)
Retired	52 (78)	30 (91)	22 (65)
Annual Household Income (CAD$			
<$40,000	8 (12)	3 (9)	5 (15)
$40,000 – $79,999	30 (45)	16 (49)	14 (41)
≥$80,000	20 (30)	7 (21)	13 (38)
Do not know/refused to answer	9 (13)	7 (21)	2 (6)
Diabetes duration (years)	19.0 (13.7)	20.0 (11.7)	18.0 (15.5)
A1c (%)	7.1 (1.2)	7.0 (1.4)	7.1 (0.9)
Total cholesterol (mmol/L)	4.4 (1.0)	4.3 (1.0)	4.5 (0.9)
HDL (mmol/L)	1.3 (0.4)	1.4 (0.4)	1.3 (0.4)
TC/HDL Ratio	3.6 (1.5)	3.3 (0.9)	3.9 (1.9)
Systolic BP (mmHg)	127.9 (12.4)	127.7 (9.9)	128.2 (14.6)
Diastolic BP (mmHg)	70.1 (10.6)	69.8 (8.1)	70.5 (12.8)
Resting Heart Rate (bpm)	77.8 (14.5)	78.8 (15.3)	76.8 (13.9)
Body Mass Index (kg/m^2)	30.1 (5.7)	28.0 (5.1)	32.0 (5.6)
Waist Circumference (cm)	107.4 (16.1)	102.5 (15.5)	112.2 (15.4)

Table A1.2: Sample Size and Power calculations

Power = 90%, α=0.05, $Z_{\alpha/2}$=1.96, Z_β=1.28, $\boldsymbol{\delta_B}$ =4

Effect size ($d=\Delta/\delta_B$)	Δ (in GI units)	N / arm	Total N	N_{new} (30% Attrition)
0.2	0.8	525	1050	1500
0.5	2.0	84	168	240
0.8	3.2	33	66	94
1.0	4.0	21	42	60

Power = 90%, α=0.05, $Z_{\alpha/2}$=1.96, Z_β=1.28, $\boldsymbol{\delta_B}$ =5

Effect size ($d=\Delta/\delta_B$)	Δ (in GI units)	N / arm	Total N	N_{new} (30% Attrition)
0.2	1.0	525	1050	1500
0.5	2.5	84	168	240
0.8	4.0	33	66	94
1.0	5.0	21	42	60

Power = 80%, α=0.05, $Z_{\alpha/2}$=1.96, Z_β=0.84, $\boldsymbol{\delta_B}$ =4

Effect size ($d=\Delta/\delta_B$)	Δ (in GI units)	N / arm	Total N	N_{new} (30% Attrition)
0.2	0.8	392	784	1120
0.5	2.0	63	126	180
0.8	3.2	25	50	71
1.0	4.0	16	32	46

Power = 80%, α=0.05, $Z_{\alpha/2}$=1.96, Z_β=0.84, $\boldsymbol{\delta_B}$ =5

Effect size ($d=\Delta/\delta_B$)	Δ (in GI units)	N / arm	Total N	N_{new} (30% Attrition)
0.2	1.0	392	784	1120
0.5	2.5	63	126	180
0.8	4.0	25	50	71
1.0	5.0	16	32	46

Formula for sample size calculation

$$N = \frac{2(Z_{\alpha/2} + Z_\beta)^2 \boldsymbol{\delta}^2}{\boldsymbol{\Delta}^2}$$

New sample size with attrition in mind:

$$N_{new} = \frac{n}{1-L}$$

Where **n** is the total number of subjects in each group not accounting for loss to follow-up,
L is the loss to follow-up rate,

A2.0 Survey Measures

A2.1 HEALD-GI – Anthropometry and Clinical Data Collection Form

HEALD
Healthy Eating and Active Living for Diabetes

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HEALD-GI - Anthropometry and Clinical Data Collection Form

Study ID					

Date of Assessment			
	DD	MM	YYYY

Sex: Male Female

Anthropometric measures			
	Measurement 1	Measurement 2	Measurement 3
Weight	kg	kg	kg
Height	cm	cm	cm
Waist circumference	cm	cm	cm
Clinical measures			
Blood Pressure	mmHg	mmHg	mmHg
Resting Heart Rate	bpm	bmp	bmp
Conduct the following point-of-care testing (attach print out):			
	HbA1c		
	Cholestech		
Behavioral Measures			
Administer the following questionnaires: Date			
	Q1-1		
	Q1-2		
	3-day Food Diary GIVEN		RETURNED
Comments			

A2.2 HEALD-GI – Baseline Demographic and Physical Activity

HEALD-GI

HEALTHY EATING & ACTIVE LIVING:

Questionnaire 1-1

Study ID: ___ ___ ___ ___

Date: ____ ____ ____

About This Questionnaire:

This is a confidential questionnaire. There are no right or wrong answers to any of these questions. Please read the questions carefully and answer each one according to what is true for you. This is a thorough questionnaire and some questions may appear similar to each other. Please answer each question to the best of your ability and please do not skip any questions.

If you have any questions while completing this questionnaire please do not hesitate to ask the study staff.

How to Record Answers:

For each question, please check the box or circle the number that matches your answer. Please select only one answer.

Here is an example of a question answered by checking a box:

1. **Do you do physical activity even when you feel tired?**
   ☑Yes • No

   Checking the "yes" box means that the above statement is true for you.

Here is an example of a question answered by circling a number:

	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree
2. I enjoy swimming.	1	2	3	(4)	5

Circling the number 4 means that you agree that you enjoy swimming.

SECTION A: About You

1. What is your current age ________years

2. How old were you when you were first diagnosed with diabetes? ________years

3. What is your marital status?

Single-Never married ☐
Married/ Common law ☐
Divorced ☐
Widowed ☐
Refuse to answer ☐

4. What is the highest level of education you have completed?

No formal school ☐
Completed grade school (grades 1-9) ☐
Completed high school ☐
Completed college or university ☐
Completed graduate education (MS or PhD) ☐

5. What is your current employment status?

Home maker ☐
Full time employee ☐
Part time employee ☐
Self employed ☐
Not in labour force-disabled ☐
Retired ☐
Unemployed ☐
Others; please specify: ______________ ☐
Refuse to answer ☐

6. Which of the following best describes your ethnic background?

Caucasian/European ☐
Aboriginal ☐
African ☐
Chinese ☐

Filipino ☐
South Asian ☐
Middle Eastern ☐
Arabic ☐
Japanese ☐
Korean ☐
Vietnamese ☐
Hispanic/ Latin American ☐
Others; please specify: ___________________ ☐
Refuse to answer ☐

7. Which of the following categories best describes your total annual household income? (this should include income, before taxes, from all sources, wages, rent from properties, social security, disability benefits, help from relatives and so on…)

Less than $20,000 ☐
$20,000-$39,999 ☐
$40,000-$59,999 ☐
$60,000-$79,999 ☐
$80,000-$99,999 ☐
Over $100,000 ☐
Don't know ☐
Refuse to answer ☐

SECTION B: Your Health Behaviours

8. How often do you smoke cigarettes? (**Check** the one box that applies to you).

☐ I've never smoked
☐ I smoke but not everyday
☐ I smoke daily ___________(enter number of cigarettes you smoke a day)
☐ I quit smoking __________years ago (enter the number of years)
On average, how many cigarettes did you smoke each day when you smoked?: __________ (enter number of cigarettes a day)

9. For the next question, we would like you to recall your average **weekly** participation in physical activity **over the past month.** On average **over the past month**, how many **times per week** did you do the following kinds of physical activity during your free time?

When answering these questions please:

- Write the average number of times per week in the first column and the average minutes per session in the second column for **strenuous**, **moderate** and **mild** physical activity.
- Only count physical activity sessions that lasted 10 minutes or longer in duration.
- DO NOT LEAVE ANY PART BLANK! If you did not participate in any of the following activities, please enter the number "0".

		Average times per week	**Average minutes per session**
a.	**Strenuous physical activity:** heart beats rapidly, sweating (e.g., running, jogging, hockey, soccer, squash, judo, vigorous swimming, vigorous long distance bicycling, vigorous aerobic dance classes, heavy weight training)		
b.	**Moderate physical activity:** not exhausting, light perspiration (e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, popular and folk dancing)		
c.	**Mild physical activity:** minimal effort, no perspiration (e.g., easy walking, yoga, archery, fishing, bowling, lawn bowling, shuffleboard, horseshoes, golf, gardening)		

Thank you for your time and participation today!

Please check that you have not missed any pages or questions.

A2.3 HEALD-GI – Follow-up Demographic and Physical Activity

HEALTHY EATING & ACTIVE LIVING FOR DIABETES

Questionnaire 2-1

Study ID: ___ ___ ___ ___

Date: ____ ____ ____

(DD) (MM) (YYYY)

About This Questionnaire:

This is a confidential questionnaire. There are no right or wrong answers to any of these questions. Please read the questions carefully and answer each one according to what is true for you. This is a thorough questionnaire and some questions may appear similar to each other. Please answer each question to the best of your ability and please do not skip any questions.

If you have any questions while completing this questionnaire please ask the study staff.

How to Record Answers:

For each question, please check the box or circle the number that matches your answer. Select only one answer.

Here is an example of a question answered by checking a box:

2. Do you do physical activity even when you feel tired?

☑ Yes • No

Checking the "yes" box means that the above statement is true for you.

Here is an example of a question answered by circling a number:

	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree
2. I enjoy swimming.	1	2	3	(4)	5

Circling the number 4 means that you agree that you enjoy swimming.

SECTION A: About You

A1. Do you currently take any of the following?

*(Please **check** the box that applies to you)*	**Yes**	**No**	**I don't know**
a. Aspirin	1☐	0☐	☐
b. Medications to control high blood pressure	1☐	0☐	☐
c. Medications to control your cholesterol levels	1☐	0☐	☐
d. Medications to protect your kidneys	1☐	0☐	☐

A2. In total, how many different prescription medications are you taking?

0☐ 0 (zero)	3☐ 3 or 4
1☐ 1	4☐ 5 to 9
2☐ 2	5☐ 10 or more

A3. Of those, how many different prescription medications are you taking to control your blood sugar level?

0☐ 0 (zero)	3☐ 3 or 4
1☐ 1	4☐ 5 to 9
2☐ 2	5☐ 10 or more

A4. During the **past 3 months** (since your baseline visit):

*(Please **check** the box that applies to you)*	**Yes**	**No**	**Not Sure**
a. Did you visit your family doctor?	1☐	0☐	☐
b. Did you visit with an allied health professional for a diabetes-related issue (e.g. pharmacist or nurse)?	1☐	0☐	☐
c. Did you visit with a dietititan?	1☐	0☐	☐
d. Did you visit an emergency room for a diabetes-related issue (e.g. hypoglycemia)?	1☐	0☐	☐

SECTION B: Your Health Behaviours

B1. How often do you smoke cigarettes? (Check the one box that applies to you).

- ☐ I've never smoked
- ☐ I smoke but not everyday
- ☐ I smoke daily ___________(enter number of cigarettes you smoke a day)
- ☐ I quit smoking __________years ago (enter the number of years)

  On average, how many cigarettes did you smoke each day when you smoked?:
  __________ (enter number of cigarettes a day)

B2. For the next question, we would like you to recall your average **weekly** participation in physical activity **over the past month.** On average **over the past month**, how many **times per week** did you do the following kinds of physical activity during your free time?

When answering these questions please:

- ➢ Write the average number of times per week in the first column and the average minutes per session in the second column for **strenuous**, **moderate** and **mild** physical activity.
- ➢ Only count physical activity sessions that lasted 10 minutes or longer in duration.
- ➢ Do not leave any part blank. If you did not participate in any of the following activities, please enter the number "0".

		Average times per week	**Average minutes per session**
a.	**Strenuous physical activity:** heart beats rapidly, sweating (e.g., running, jogging, hockey, soccer, squash, judo, vigorous swimming, vigorous long distance bicycling, vigorous aerobic dance classes, heavy weight training)		
b.	**Moderate physical activity:** not exhausting, light perspiration (e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, popular and folk dancing)		
c.	**Mild physical activity:** minimal effort, no perspiration (e.g., easy walking, yoga, archery, fishing, bowling, lawn bowling, shuffleboard, horseshoes, golf, gardening)		

A2.4 HEALD-GI – Glycemic Index Questionnaire (Baseline and Follow-Up)

Athabasca University
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HEALD
Healthy Eating and Active Living for Diabetes

UNIVERSITY OF ALBERTA
QUAECUMQUE VERA

ABCD
Alberta's Caring for Diabetes Project

HEALTHY EATING & ACTIVE LIVING FOR DIABETES

Questionnaire 2-2

Study ID: ___ ___ ___ ___

Date: ____ ____ ____

(DD) (MM) (YYYY)

SECTION A: Managing Your Diabetes

We would like to know about your diabetes self-care activities during the **last seven days**. If you were sick during the past 7 days, please think back to the last 7 days that you were not sick. (Please circle the number that applies to you.)

A1. Diet (Use Canada's Food Guide as reference for healthy eating)

a. How many of the **last seven days** have you followed a healthful eating plan?							
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
b. On average, **over the past month**, how many **days per week** have you followed your eating plan?							
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
c. On how many of the **last seven days** did you eat five or more servings of fruits and vegetables?							
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
d. On how many of the **last seven days** did you eat high fat foods such as red meat or full-fat dairy products?							
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**

A2. Do you know what the Glycemic Index is: ☐ **Yes** ☐ **No**

A3. Do you consistently avoid eating high Glycemic Index foods? (Circle only one answer)

1	**2**	**3**	**4**	**5**
No, and I do not plan to do so in the next 6 months	No, but I was thinking about doing so in the next 6 months	No, but I planned to in the next 30 days	Yes, but I have only begun in the past 6 months	Yes, and I have been doing so for longer than 6 months

A4. Do you normally choose low Glycemic Index foods? (Circle only one answer)

1	**2**	**3**	**4**	**5**
No, and I do not plan to do so in the next 6 months	No, but I was thinking about doing so in the next 6 months	No, but I planned to in the next 30 days	Yes, but I have only begun in the past 6 months	Yes, and I have been doing so for longer than 6 months

SECTION B: Glycemic Index

For the rest of the questions, please use the following definition of glycemic index and tips on how to include low glycemic index foods in your diet.

According to the Canadian Diabetes Association Clinical Practice Guidelines (2013), the glycemic index is a scale that ranks carbohydrate-rich foods by how much they raise blood sugar levels compared to a standard food. The standard food is white bread.

To include low glycemic index foods, enjoy vegetables, fruits and low-fat milk products with your meals. These are carbohydrate-rich foods that, in general, have low glycemic index. Try foods, such as barley, bulgar, couscous, lentils or brown rice, which have a low glycemic index.

We would like to know about your low glycemic index dietary self-care practices. (Please circle the number that best applies to you.)

B1. How would you describe your understanding of the glycemic index concept?

Never heard of it	Heard of it but didn't understand	Heard of it and tried to make changes	Heard of it and made changes	Heard of it and have good understanding
1	2	3	4	5

B2. How would you rank your understanding of the glycemic index?

Very good	Good	Fair	Poor	Very poor
1	2	3	4	5

For the following questions, please circle the best answer according to your opinions on selecting low glycemic index foods. Many questions use a rating scale; please circle the number that best describes your opinion on the scale. Never circle more than one number on a single scale.

	Strongly disagree						Strongly agree
B3. Eating low glycemic index foods more often may improve my blood sugar readings	1	2	3	4	5	6	7
B4. Choosing low glycemic index foods more often is a Lifestyle change that helps to better manage my diabetes	1	2	3	4	5	6	7

B5. I am afraid eating low glycemic index foods more often may cause **high** blood sugar readings	1	2	3	4	5	6	7
B6. If I eat low glycemic index foods more often, I can eat as many high glycemic index foods as I want	1	2	3	4	5	6	7

B7. My eating low glycemic index foods more often in the next two weeks would be

Extremely bad						Extremely good
1	2	3	4	5	6	7

B8. My eating low glycemic index foods more often in the next two weeks would be

Extremely harmful						Extremely beneficial
1	2	3	4	5	6	7

B9. Because low glycemic index foods may taste bad, my eating them more often in the next two weeks would be

Extremely unpleasant						Extremely pleasant
1	2	3	4	5	6	7

B10. Because low glycemic index foods may take too long to prepare, eating them more often in the next two weeks would be

Extremely inconvenient						Extremely convenient
1	2	3	4	5	6	7

B11. My eating low glycemic index foods more often in the next two weeks would be

Extremely unwise						Extremely wise
1	2	3	4	5	6	7

B12. My eating low glycemic index foods more often in the next two weeks would be

Extremely unnecessary						Extremely necessary
1	2	3	4	5	6	7

B13. My eating low glycemic index foods more often in the next two weeks would be

Extremely unenjoyable						Extremely enjoyable
1	2	3	4	5	6	7

B14. People who are important to me think that **I should not/I should** eat low glycemic index foods more often

I should not						I should
1	2	3	4	5	6	7

B15. People who are important to me would **disapprove/approve** of my eating low glycemic index foods more often in the next two weeks

Disapprove						Approve
1	2	3	4	5	6	7

B16. People who are important to me want me to eat low glycemic index foods more often in the next two weeks

Strongly disagree						Strongly agree
1	2	3	4	5	6	7

B17. Many people who are important to me eat low glycemic index foods more often

Extremely unlikely						Extremely likely
1	2	3	4	5	6	7

B18. The people in my life whose opinions I value eat low glycemic index foods more often

Strongly disagree | Strongly agree

1	2	3	4	5	6	7

B19. I have self-discipline to eat low glycemic index foods more often in the next two weeks

No self-discipline						Complete self-discipline
1	2	3	4	5	6	7

B20. I have the ability to eat low glycemic index foods more often in the next two weeks

Definitely do not						Definitely do
1	2	3	4	5	6	7

B21. My eating low glycemic index foods more often in the next two weeks would be

Difficult						Easy
1	2	3	4	5	6	7

B22. How confident are you that you will be able to eat low glycemic index foods more often in the next two weeks?

Not very confident						Very confident
1	2	3	4	5	6	7

B23. If it were entirely up to me, I am confident that I would be able to eat low glycemic index foods more often in the next two weeks

Strongly disagree						Strongly agree
1	2	3	4	5	6	7

	Strongly disagree						Strongly agree
B24. I intend to eat low glycemic index foods more often in the next two weeks	1	2	3	4	5	6	7
B25. I want to eat low glycemic index foods more often in the next two weeks	1	2	3	4	5	6	7
B26. I plan to eat low glycemic index foods more often in the next two weeks	1	2	3	4	5	6	7

C: Glycemic index knowledge		Very Poor	Poor	Unsure	Good	Very Good
C1.	How would you describe your knowledge of the glycemic index concept?	1	2	3	4	5
C2.	What is your confidence level when identifying low glycemic index foods?	1	2	3	4	5
C3.	What is your confidence level for regularly consuming low glycemic index foods?	1	2	3	4	5
C4.	How good are low glycemic index carbohydrates for your health?	1	2	3	4	5
D: When choosing low glycemic index foods, I am concerned:		Almo st never	Less than half of the time	Half the time	Over half of the time	Almost always
D1.	I will have gastrointestinal (digestive) problems.	1	2	3	4	5
D2.	They will take too long to prepare.	1	2	3	4	5
D3.	They will cost too much.	1	2	3	4	5
D4.	They will taste bad.	1	2	3	4	5
D5.	My family or friends won’t approve.	1	2	3	4	5
D6.	I won’t know how to prepare them.	1	2	3	4	5
D7.	The choice is limited.	1	2	3	4	5

E: Glycemic control	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
E1. Eating low glycemic index foods improves blood sugar readings.	1	2	3	4	5
E2. I am afraid eating low glycemic index foods will cause **high** blood sugar readings.	1	2	3	4	5
E3. I am afraid eating low glycemic index foods will cause **low** blood sugar readings.	1	2	3	4	5

F: Weight management	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
F1. Eating low glycemic index foods will help with weight management.	1	2	3	4	5
F2. Eating low glycemic foods will decrease my hunger between meals.	1	2	3	4	5

G: Energy level and exercise	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
G1. Eating low glycemic index foods will give me more energy.	1	2	3	4	5
G2. Eating low glycemic index foods will help me to be more physically active.	1	2	3	4	5

H: Lifestyle change	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
H1. Lifestyle change, rather than	1	2	3	4	5

	"going on a diet", is the most effective way to better manage my diabetes.					
H2.	Choosing low glycemic index foods is a lifestyle change that helps to better manage my diabetes.	1	2	3	4	5
H3.	Choosing low glycemic index foods as a permanent lifestyle change to better manage my diabetes is an achievable goal.	1	2	3	4	5

SECTION I: How you feel

I1. In the last 3 months, have you noticed any changes in the following:

Please put an "X" under the answer (*Yes* or *No*) that is best for you. Then, if yes, please put an arrow pointing up for increased symptoms and an arrow pointing down for decreased symptoms

	Yes	No	
Constipation			
Hunger between meals			
Bloating			
Diarrhea			
Nausea			
Stomach Ache			
Gas or flatulence or farting			
Other: ____________			
Other: ____________			

A2.5 HEALD-GI – Computer Proficiency Questionnaire

HEALD
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Computer Proficiency Questionnaire

This questionnaire asks about your ability to perform a number of tasks with a computer. Please answer each question by placing an **X** in the box that is most appropriate. If you have not tried to perform a task or do not know what it is, please mark '**Never tried**', regardless of whether or not you think you may be able to perform the task.

Computer and Printer Basics

I can:	Never tried	Not at all	Not very easily	Some-what easily	Very easily
Use a computer keyboard to type					
Use a mouse					
Load ink into the printer					
Fix the printer when paper jams					

Communication

I can:	Never tried	Not at all	Not very easily	Some-what easily	Very easily
Open emails					
Send emails					
Chat using Internet chat rooms					

Internet

I can:	Never tried	Not at all	Not very easily	Some-what easily	Very easily
Find information about local community resources on the Internet					
Find information about my hobbies and interests on the Internet					
Bookmark websites to find them again later (e.g. make favourites)					
Save text and images I find on the Internet					

Calendar

I can:	Never tried	Not at all	Not very easily	Some-what easily	Very easily
Use a computer to enter events and appointments into a calendar					
Check the date and time of upcoming appointments					

Entertainment

I can:	Never tried	Not at all	Not very easily	Some-what easily	Very easily
Use a computer to watch movies and videos					
Use a computer to listen to music					

A2.6 HEALD-GI – Participants' Reminder Preference Form

HEALD
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Study Participants' Reminder Preference Form

1. I would like to receive periodic reminders to visit the study website and to use print materials to acquire knowledge about healthy eating practices.

- [ ] Yes
- [ ] No

2. If yes, how often would you like a reminder?

- [ ] Twice a week
- [ ] Once a week
- [ ] Once another module becomes available (every 2 weeks)
- [ ] Once a month
- [ ] Never

3. If you would like reminders, please identify the method you most prefer:

- [ ] Email
- [ ] Text (SMS)
- [ ] Telephone call
- [ ] Postal mail

4. My contact detail(s) is/are

____
____
____
____
____
____

Thank you for your time and participation today!

Please check that you have not missed any pages or questions.