Development, Implementation and Evaluation of a Daily Physical Activity intervention for Individuals with Type 2 Diabetes

By

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In memory of my parents

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Abstract

The ultimate aim of this project was to develop an effective and acceptable physical activity intervention for individuals with Type 2 diabetes that was also feasible for diabetes educators to deliver. A program theory, formulated from published literature and in collaboration with diabetes educators and individuals with Type 2 diabetes, was used to drive the program design as well as the evaluation of this pilot intervention.

The primary confusion in the literature is a result of: 1) the misuse and/or preferential uses of the terms exercise or physical activity; and, 2) the difficulty in measuring physical activity. Physical activity can be a complex pattern of behaviour reflecting both the daily demands of unique individual life situations and intentional, or elective, activities. At its most complex levels, dimensions of physical activity volume include frequency, intensity, duration and type. Guidelines for increasing physical activity in general populations and in individuals with Type 2 diabetes are a reflection of this confusion and diabetes educators are frustrated about how to best counsel their clients. Individuals with Type 2 diabetes are typically sedentary and have difficulty adhering to structured exercise guidelines. The demands of diabetes self-management preclude such a complex prescriptive approach to increasing physical activity. Individuals with Type 2 diabetes want an acceptable and effective program.

The First Step Program is an 8-week program designed to incrementally increase physical activity levels in sedentary individuals with Type 2 diabetes. The program is divided into two distinct phases directed at adoption and adherence, respectively. The adoption phase consists of four weekly education and counseling meetings (in a group or face-to-face setting), combined with individual goal-setting and self-monitoring using a pedometer for feedback. The adherence

phase occurs over a subsequent 4-week period with continued individual self-monitoring using a pedometer and reduced professional contact.

The formative evaluation (including qualitative methods) of the pilot program supported the acceptability of the First Step Program (to both educators and clients), especially with regards to self-monitoring using a pedometer in combination with an activity calendar. In contrast, follow-up contact via telephone was inefficient and unacceptable (to both stakeholder groups). The primary recruitment issue that emerged was determining who was sedentary. A number of self-report methods were evaluated and discarded as unacceptable. Recommendations for using baseline pedometer results to classify sedentarism, although not practiced in the pilot program, is currently being evaluated in a randomised controlled trial of the First Step Program.

In terms of the primary intended outcome (physical activity defined as steps/day), the summative, or impact evaluation showed dramatic results over four months. The pilot sample consisted of 9 sedentary individuals (3 males, 6 females; average age 53±6 years) with Type 2 diabetes. Physical activity increased significantly from baseline (T1) and remained elevated for the duration of the study period ($p<0.05$). At T1, subjects averaged (±SD) 6,342±2,244 steps/day. After one month of programming (T2), subjects significantly increased their steps/day: 10,115±3407. After a second month of individual daily activity (T3), activity levels did not differ from T2 but remained elevated from T1 (8,939±2,760). At 2 months post-intervention (T4), daily physical activity remained elevated from T1 (8,830±2,772) and did not differ from the other time points. This increase from baseline translates into an extra 22.6 minutes of walking a day for this population. Improvements in other outcomes (blood pressure, waist girth, cardiorespiratory fitness) support a valid change in physical activity. Although preliminary, these promising results provide support for further evaluation directed towards dissemination.

Chapter 1: Introduction and Overview

1.1 Statement of the Problem

Type 2 diabetes is a chronic condition associated with long-term micro- and macrovascular complications including retinopathy, nephropathy, peripheral and autonomic neuropathy, and cardiovascular disease. These complications potentially result in vision loss, renal failure, foot ulcers and/or amputation, gastrointestinal, genitourital, and sexual dysfunction, and fatalities due to cardiovascular disease (including myocardial infarction and stroke). Diabetes is ranked the seventh leading cause of death in Canada (Health Canada, 1999). The actual number of deaths for which diabetes was a contributing factor is estimated to be five times as high as current death certificates indicate (Health Canada, 1999).

The frequency of hospitalization of older individuals with Type 2 diabetes is twice as high as for those without diabetes (Rosenthal, Fajardo, Gilmore, Morley, & Naliboff, 1998). A similar finding is apparent with use of home health care services (Health Canada, 1999). In 1992, individuals with diabetes mellitus represented 3.1% of the United States population but accounted for 11.9% ($85 billion) of total health care expenditures (Rubin, Altman, & Mendelson, 1994). Estimated expenditures in 1997 attributable to diabetes totaled $98 billion (American Diabetes Association, 1998b). In Canada, the economic burden of diabetes and related complications is estimated to be up to $9 billion (US) (Health Canada, 1999).

Pharmaceutical therapy aimed at tightly controlling hyperglycemia is considered a cost-effective strategy that can result in reduced complications, improved quality of life, and potentially improve longevity in Type 1 (Diabetes Control and Complications Trial Research Group, 1996) and Type 2 diabetes (Ohkubo et al., 1995; UK Prospective Diabetes Study Group, 1998a). In addition, controlling hypertension (commonly associated with Type 2 diabetes) through pharmaceutical means reduces fatalities due to myocardial infarction and stroke (UK Prospective Diabetes Study Group, 1998b). Non-pharmaceutical interventions for Type 2 diabetes that can produce similar effects are urgently needed.

1.2 Operational Definition, Diagnosis, and Classification

Diabetes mellitus is a heterogeneous group of metabolic disorders characterized by hyperglycemia due to abnormalities in insulin secretion, action, or both. Recently, an International Expert Committee, sponsored by the American Diabetes Association (ADA), recommended changes to the classification and diagnosis of subgroups of diabetes originally set out by the National Diabetes Data Group (NDDG) in 1979 and later endorsed by the World Health Organization (WHO; 1985). The changes reflect a more etiological, less pharmacological, classification system. Type 1 diabetes is a result of an absolute insulin deficiency whereas the more prevalent Type 2 diabetes is caused by a combination of target tissue resistance to insulin action and a compromised compensatory insulin response (ADA, 1997). Criteria for diagnosing Type 2 diabetes are based on measures of hyperglcemia: fasting plasma glucose ≥7.0 mmol/L or ≥11.1mmol/L 2 hours post-75 gram glucose load (Meltzer et al., 1998). Classical symptoms of hyperglycemia include polyuria, polydipsia, and unexplained weight loss. Glycation of tissue proteins and the accumulation of polyol compounds produced under hyperglycemic conditions are believed to be the mechanisms underlying the complications of diabetes (Giardio & Brownlee, 1997; Wolffenbuttel & Haeften, 1995). The degree of hyperglycemia can change over time and reflects the severity of the disease process (ADA, 1997).

1.3 Incidence and Prevalence

An estimated 124 million people worldwide have diabetes, 97% of whom have Type 2 diabetes (Amos, McCarty, & Zimmet, 1997). A Canadian survey of self-reported diabetes indicated a prevalence of 5% in the adult population (Reeder et al., 1992). Lemay (1988) estimated that between 500,000 and 640,000 Canadians were afflicted with diabetes in 1986. A current national survey indicates that 1.2-1.4 million Canadians over the age of 12 have diabetes (Health Canada, 1999). The prevalence of diabetes increases with age (Health Canada, 1999; Tan & MacLean, 1995). Population ageing is expected to dramatically increase the number of older individuals with diabetes (Casparie, 1991; Helms, 1992).

Ascertainment of true prevalence is complicated due to the insidious onset of this disease; asymptomatic disease can progress undetected for 4 to 7 years (Harris, Klein, Welborn, & Knuiman, 1992). The prevalence of unascertained Type 2 diabetes has been estimated to approximately equal that of diagnosed disease (Harris, Hadden, Knowler, & Bennett, 1987). Of the 1.2-1.4 million Canadians over the age of 12, only about 800,000 are diagnosed cases (Health Canada, 1999).Using a clinical measure such as an oral glucose tolerance test (OGTT), a prevalence rate of 17%, among the highest in the world, was reported in a Native Canadian population (Harris et al., 1997). Epidemiological data presented here reflect the earlier classification system based on the 1985 WHO recommendations . Using fasting plasma glucose as the newly recommended diagnostic criteria will likely lead to slightly lower estimates of prevalence (ADA, 1997).

Hammertrand, Young, and Roos (1991) reported a trend for increased incidence of diagnosed diabetes in a Manitoba population aged 25 and over (5.4 per 1000 persons in 1975-

1976 to 7.8 per 1000 persons in 1983-1984), likely reflecting better detection procedures. Over the subsequent decade, the incidence of diabetes in Manitoba remained relatively stable at approximately 5.6 per 1000 persons (Blanchard et al., 1996). Incidence also increases with age, indicating either a temporal increase or improved detection with screening at older ages (Warram, Kopczynski, Janka, & Krolewski, 1997).

1.4 Pathophysiology

The pathophysiology of Type 2 diabetes includes, to varying degrees, hyperinsulinemia, resistance to the actions of insulin, increased hepatic glucose output, compromised pancreatic beta cell secretory functions, and hyperglycemia.

Insulin resistance is defined as the inability of insulin to produce its expected biological effects at normal circulating concentrations (Kahn, 1978). *Insulin sensitivity* is the reciprocal definition; it is the percentage of maximal biological response produced by submaximal levels of insulin (Kahn, 1978). In the research literature, insulin resistance and insulin sensitivity are often used interchangeably to convey relative ability of insulin to produce expected effects.

Insulin acts normally to clear blood glucose by promoting glucose transport from the circulation into peripheral tissues, especially skeletal muscle. It also suppresses hepatic glucose output by inhibiting gluconeogenesis and glycogenolysis. Finally, insulin inhibits adipose tissue lipolysis. Insulin resistance is expressed as an elevated hepatic glucose production (the primary determinant of fasting plasma glucose) and a reduced peripheral glucose uptake (more responsible for postprandial hyperglycemia and described as a decreased glucose tolerance)(DeFronzo, 1988). Insulin resistance also results in elevated circulating plasma fatty acids (Brown, 1994), which, in turn, may further aggravate hyperglycemia (Yki-Jarvinen & Williams, 1997).

Although a subject of debate, insulin resistance, characterized by hyperinsulinemia, usually precedes hyperglycemia in obese individuals with Type 2 diabetes (Olefsky & Nolan, 1995), but insulin resistance alone is not sufficient for a diagnoses of diabetes. Obese and otherwise insulin-resistant individuals avoid the consequences of diabetes unless hyperglycemia occurs (Polonsky, Sturis, & Bell, 1996). At this point, glucotoxicity (chronic hyperglycemia) contributes to pancreatic beta cell dysfunction and increased insulin resistance (Yki-Jarvinen, 1997). Relief of glucotoxicity improves insulin secretion in vivo (Kosaka, Kuzuya, Akanuma, & Hagura, 1980; Vague & Moulin, 1982).

1.4 Risk Factors

Type 2 diabetes is considered to be multifactorial in its determinism, resulting from a heterogeneous combination of polygenic defects and environmental factors (Dagogo-Jack & Santiago, 1997; Kahn, Vicent, & Doria, 1996; Sacks & McDonald, 1995), together leading to disrupted glucose homeostasis. Type 2 diabetes has been described as the result of a "collision between thrifty genes and an affluent society" (Groop & Tuomi, 1997); an inherited ability to store and conserve energy efficiently, when exposed to a sedentary lifestyle and high caloric intake, is predisposed to insulin resistance and obesity. Insulin resistance is commonly considered the central feature linking a number of metabolic and vascular abnormalities characterized as Syndrome X (Reaven, 1993).

Type 2 diabetes aggregates in families (Klein, Klein, Moss, & Cruickshanks, 1996a; Simmons, Gatland, Leakehe, & Fleming, 1995); complete concordance rates from twin studies have been reported (Barnett, Eff, Leslie, & Pyke, 1981). Twin studies represent the maximal heritability, but do not control easily for shared environmental factors or gene interaction effects

(Hawkes, 1997). Similar problems are apparent in family studies. Regardless of mechanism, familial resemblance is considered an important risk factor (Barcelo, 1996).

Age is an independent risk factor for impaired glucose tolerance and the development of Type 2 diabetes, due primarily to age-related increases in insulin resistance (Katz & Lowenthal, 1994), which is itself a risk factor (Skarfors, Selinus, & Lithell, 1991).

The two most important modifiable risk factors for the development of Type 2 diabetes are obesity and physical inactivity (Health Canada, 1999). Dietary factors leading to obesity contribute to diabetes risk (Barcelo, 1996). Overall obesity is generally related to Type 2 diabetes (Rabkin et al., 1997), but the effect may be modified by family history (Haffner, 1995). Regional adiposity, specifically, subcutaneous truncal adipose tissue, is more closely related to insulin resistance than generalized adiposity (Abate, 1996) and is a better predictor of Type 2 diabetes (Carey et al., 1996; Lundgren, Bengtsson, Blohme, Lapidus, & Sjostrom, 1989; Ohlson et al., 1985).

Cross-sectional studies indicate that physical inactivity is related to Type 2 diabetes (Dowse et al., 1991; Kaye, Folsom, Sprafka, Prineas, & Wallace, 1991; Rabkin et al., 1997). Increased participation in non-vigorous, as well as vigorous physical activity has been associated with improved insulin action in a large cross-sectional study of men and women (which included those with impaired glucose tolerance and Type 2 diabetes) of diverse cultures (Mayer-Davis et al., 1998). Retrospective studies of both historical leisure-time physical activity (Kriska et al., 1993) and participation in community-based structured exercise programs (Heath, Leonard, Wilson, Kendrick, & Powell, 1987) provide additional evidence of the benefits of physical activity. Longitudinal studies have also shown an inverse relationship between physical activity and the onset of Type 2 diabetes (Manson et al., 1992; Manson et al., 1991). For each 500 kilocalorie increment in daily energy expenditure, the risk of diabetes is reduced by 6 percent (Helmrich, Ragland, Leung, & Paffenbarger, 1991). After controlling for the effects of age, smoking, alcohol consumption, and parental diabetes, men with low cardiorespiratory fitness (objectively determined by a maximal treadmill exercise test) had a 3.7-fold increased risk of developing Type 2 diabetes over 6 years compared with a high-fit group (Wei et al., 1999).

Structured exercise interventions have successfully reduced the incidence of Type 2 diabetes in individuals with impaired glucose tolerance (Eriksson & Lingarde, 1991; Pan et al., 1997) and recommendations have been made for the implementation of community-based programs incorporating structured exercise as a strategy to prevent Type 2 diabetes (Paffenbarger, Lee, & Kampert, 1997; Simmons, Voyle, Swinburn, & O'Dea, 1997).

1.6 Management of Type 2 Diabetes

A number of diabetes-related degenerative complications are associated with the underlying metabolic disturbances, but especially with hyperglycemia (Klein, Klein, & Moss, 1996b; Laakso, 1996). Chronic hyperglycemia results in both reversible and irreversible changes in susceptible tissue proteins (Giardio & Brownlee, 1997). Intensive management, or "tight control", of Type 2 diabetes refers to a treatment goal of normal or near-normal glycemia (Henry, 1996). Intensive management of blood glucose levels with insulin therapy delays the progression of microvascular complications in Type 1 diabetes (Diabetes Control and Complications Trial Research Group, 1993; Reichard, Nilsson, & Rosenqvist, 1993). Similar findings have been reported for intensive insulin therapy in predominantly lean Japanese patients with Type 2 diabetes (Ohkubo et al., 1995). The UK Prospective Diabetes Study (1998a) has provided further evidence of the benefits of intensive blood glucose control with regards to microvascular complications, but not macrovascular disease (i.e., myocardial infarction, stroke) in Type 2 diabetes. Based on such evidence, the treatment goal of near-normal glycemia recommended for individuals with Type 2 diabetes appears to be a sensible approach (Meltzer et al., 1998).

A stepped approach to management as the disease progresses includes oral hypoglycemic agents (sulfonylureas, metformin, acarbose, or troglitazone) and/or insulin therapy (McFarland, 1997). Diet and exercise is emphasized in the early management of Type 2 diabetes (Barnard, Jung, & Inkeles, 1994; Henry & Genuth, 1996). The much anticipated Canadian Diabetes Association (CDA) clinical guidelines have taken a progressive step forward by acknowledging the important role of physical activity and exercise in the management of Type 2 diabetes at all stages of treatment (Meltzer et al., 1998).

The diabetes educator is a likely vehicle for the delivery of messages to increase activity (Tudor-Locke, 1997). A diabetes educator is part of a collaborative team approach to diabetes education and management. The team includes, first and foremost, the individual with diabetes, and may include other supporting members such as a dietitian, nurse, pharmacist, psychologist, physician, physiotherapist, and/or social worker. In Canada, one of these team members is also typically a diabetes educator, trained to transfer appropriate knowledge about individual treatment and self-management plans.

In practice, messages to increase physical activity are not specific (i.e., get more exercise, increase your activity) (Krug, Haire-Joshu, & Heady, 1991; Ruggiero et al., 1997). The oftentimes vague and confusing educational messages are a reflection of available standards and guidelines, which are themselves inconsistent and confusing (Tudor-Locke, Myers, Rodger, & Ecclestone, 1998). We found that recommendations (published in forms accessible to diabetes educators) for frequency ranged from three days per week to daily and those for duration vary from 15 to 60 minutes. Intensity, meanwhile, was described using heart rate, perceived exertion, percentage of maximal aerobic capacity, and/or descriptive statements such as "breathing harder" or "sweating" (Tudor-Locke et al., 1998).

In 1997, the ADA and the American College of Sports Medicine (ACSM) published joint position papers regarding diabetes and exercise (the term physical activity is only used in the summary) in their respective journals . According to these recognized authorities, exercise regimens at an intensity of 50-80% of maximal aerobic capacity (VO_2 *max*), 3-4 times a week, for 30-60 minutes, result in the greatest improvements in glycemic control and insulin sensitivity. Within the same documents, however, concluding statements endorse the 1996 Surgeon General's Report on Physical Activity and Health that recommends that individuals should accumulate 30 minutes of moderate physical activity on most, if not all, days of the week. Canada has put forward a similar public health message for the general population, expanding the message to include an option to accumulate 60 minutes of daily "light effort" activities such as light walking, volleyball, easy gardening, and stretching (Health Canada & Canadian Society for Exercise Physiology, 1998). There is significant debate about the appropriateness of these messages (Bercovitz & Skinner, 1996; Blair & Connelly, 1996). Regardless, such mixed messages continue to frustrate programming efforts. Further, although we know a great deal about implemented structured and class-based exercise programming, we know very little about the delivery of physical activity interventions based on these new public health recommendations.

1.7 Rationale and Objectives of the Present Thesis

The present thesis was undertaken as a progressive course of study directed towards developing, implementing, and evaluating a feasible and acceptable physical activity intervention for individuals with Type 2 diabetes. *Physical activity* is defined as any bodily movement produced by skeletal muscles that results in energy expenditure, whereas *exercise* is a subcategory of physical activity defined as planned, structured movement undertaken to improve or maintain one or more aspect of physical fitness (Caspersen, Powell, & Christenson, 1985). The terms physical activity and exercise are not interchangeable, however, the literature is rife with the misuse of both. The focus of this thesis is on the role of physical activity, including the subset of exercise, in the management of Type 2 diabetes. Great pains were taken to represent the terms correctly throughout this thesis. When reviewing the literature, however, the original term as presented by the authors was retained to avoid misrepresenting their intentions.

The literature review presented in Chapter 2 addresses the physiological responses to exercise; the issues and considerations in physical activity epidemiology; and the psychological aspects of physical activity (specifically exercise) adoption and adherence; all within the context of Type 2 diabetes. Most importantly, Chapter 2 critiques the published studies on physical activity interventions carried out with this population to date.

Chapter 3 presents an evaluation of a popular approach to categorizing individual intention to increasing exercise (based on the stages of change model) with respect to its ability to discriminate physical activity levels determined by multiple methods. This study was carried out in a predominantly non-diabetic population as a means of both pilot testing various instruments of physical activity measurement and determining the best methods of classifying sedentarism. A number of issues of physical activity epidemiology are confronted and discussed.

The study described in Chapter 4, meanwhile, was written as a response to the suspiciously high levels of physical activity reported in a sample of newly diagnosed individuals with Type 2 diabetes, contrary to the applicable literature which characterizes this population as typically sedentary. This sample was re-contacted by telephone and interviewed using another frequently used instrument designed to assess the previous week's physical activity. The results were analyzed and compared using two different methods to present rates of sedentarism. Although the findings did not influence the study presented in Chapter 5, they have been used to justify alternative and more objective methods of screening for physical activity in a subsequently planned randomised and controlled trial.

Finally, Chapter 5 presents the systematic development, implementation, and evaluation of a novel physical activity intervention for this population: the First Step Program. Briefly, the First Step Program in an 8 week intervention which uses a pedometer to both monitor daily physical activity and motivate self-determined increases in physical activity. This chapter begins with a detailed presentation of the theory driving the program design and the framework for subsequent evaluation. The next section presents the formative evaluation of the pilot First Step Program (including a detailed program description) and a summative evaluation of the program's impact. The lessons learned from these evaluations formed the bases for the final recommendations which concerns both programming applications and future needed research.

Chapter 2: Literature Review

2.1 Introduction

Within the context of the target population, this literature review is separated into four distinct sections: 1) physiological response to physical activity (specifically to exercise); 2) physical activity epidemiology (especially with regards to classification and measurement); 3) behavioural perspective of physical activity (specifically exercise) adoption and adherence; and finally, 4) a critique of published physical activity interventions carried out in this population to date. This chapter lays the groundwork and rationale to develop and evaluate a new approach to increasing physical activity (as part of a self-management approach) in individuals with Type 2 diabetes.

2.2 Physiological Response to Physical Activity (Exercise)

As defined earlier in Chapter 1, exercise is a subcategory of physical activity defined as planned, structured movement undertaken to improve or maintain one or more aspect of physical fitness (Caspersen et al., 1985). Both the acute and long-term effects of exercise in individuals with Type 2 diabetes have been the subject of a number of reviews (Bonen, 1995; Eriksson, 1999; Goodyear, 1998; Ivy, 1997; Ivy, Zderic, & Fogt, 1999; Koivisto & DeFronzo, 1984; Wallberg-Henriksson, Rincon, & Zierath, 1998; Zierath & Wallberg-Henriksson, 1992). We separate this section into two parts: 1) a discussion of both immediate and long-term effects of endurance exercise on glycemic control and insulin sensitivity; and, 2) other long-term physiological responses to endurance exercise that are of particular importance to the Type 2 diabetic population. Emerging interest in the physiological response to resistance training in this population warrants a separate discussion at the end of this section. One additional point is necessary to prepare the reader: the majority of studies have been conducted on obese individuals with Type 2 diabetes. Reference is made to the exception where necessary.

2.2.1 Glycemic Control and Insulin Sensitivity

2.3.1.1 Acute/immediate effects

Glucose levels are tightly regulated in healthy individuals. As blood glucose declines due to exercise, hepatic glycogenolysis and gluconeogenesis quickly counter fluctuations in plasma glucose concentration (Richter, Turcotte, Hespel, & Kiens, 1992). In contrast, in obese individuals with Type 2 diabetes, a single bout of moderate to high intensity exercise acutely decreases plasma blood glucose in the fasting condition (Hubinger, Franzen, & Gries, 1987; Martin, Katz, & Wahren, 1995; Minuk et al., 1981), and post-prandially (Larsen, Dela, Kjaer, & Galbo, 1997) which persists into the post-exercise period (Hubinger et al., 1987; Larsen et al., 1997; Minuk et al., 1981), and is reversed with a subsequent meal (Larsen et al., 1997). Duration of activity is related to the observed decrease in blood glucose (Paternostro-Bayles, Wing, & Robertson, 1989). This glucose lowering effect is not necessarily observed in lean patients (Jenkins, Furler, Bruce, & Chisholm, 1988), reflecting the heterogeneity of Type 2 diabetes. Post-exercise hyperglycemia in obese individuals has been reported following maximal dynamic exercise (Kjaer et al., 1990), likely due to an exaggerated counter-regulatory hormonal response. Hypoglycemia, considered a significant side effect of intensive glycemic control, is less common feature of Type 2 diabetes compared with Type 1 diabetes (Gaster & Hirsch, 1998).

In nondiabetic individuals, moderate to vigorous exercise reduces insulin secretion and therefore plasma insulin levels (Galbo, 1983). Plasma insulin levels are also reduced through exercise in individuals with Type 2 diabetes (Hubinger et al., 1987; Krotkiewski & Gorski, 1986;

Larsen et al., 1997; Minuk et al., 1981) but the effect appears to be attenuated when compared with obese nondiabetic controls (Krotkiewski & Gorski, 1986; Minuk et al., 1981). There is ample evidence that insulin sensitivity, determined by glucose clearance rate, is enhanced in obese individuals with Type 2 diabetes 1-12 hours following a single bout of dynamic exercise (Burstein, Epstein, Shapiro, Charuzi, & Karnieli, 1990; Devlin, Hirshman, Horton, & Horton, 1987). Both moderate intensity (50% of VO_2 *max*) and high intensity (75% of VO_2 *max*) treadmill exercise (adjusted so that duration and energy expenditure were equivalent) have been shown to produce similar acute improvements in insulin sensitivity in obese women with Type 2 diabetes (Braun, Zimmerman, & Kretchmer, 1995). A plausible mechanistic explanation for these effects is that muscular contractions improve skeletal muscle glucose uptake directly and by enhancing insulin's action (Cortright & Dohm, 1997).

2.3.1.2 Long-term training effects

Early exercise training studies showed no improvements in insulin action or glycemic control (Ruderman, Granda, & Johansen, 1979; Saltin et al., 1979). These studies have been criticized for a number of design problems including insufficient intensity and duration, delayed post-assessment, and inclusion of individuals with severe disease treated by insulin (Ivy et al., 1999).

Correcting for these problems, more recent studies have reported that fasting plasma glucose levels are lowered with training in individuals with Type 2 diabetes (Holloszy, Schultz, Kusnierkiewicz, Hagberg, & Ehsani, 1986; Reitman, Vasquez, Klimes, & Nagulesparan, 1984). One year of vigorous training normalized fasting plasma glucose in individuals described as "mildly diabetic" (Holloszy et al., 1986). Observed improvements in glycemic control may be due to the cumulative effects of transient improvements in plasma glucose levels that follow exercise (Rogers et al., 1988; Schneider, Amoros, Khachadurian, & Ruderman, 1984).

Glucose tolerance (determined orally or intravenously) is improved with exercise training in some (Bogardus et al., 1984; Holloszy et al., 1986; Reitman et al., 1984; Rogers et al., 1988; Trovati et al., 1984), but not all investigations in individuals with Type 2 diabetes (Allenberg, Johansen, & Saltin, 1988; Krotkiewski et al., 1985; Lampman & Schteningart, 1991; Reitman et al., 1984; Schneider et al., 1984; Skarfors, Wegener, Lithell, & Selinus, 1987). Levels of HbA_{1C}, an indicator of recent glycemic control, have improved (Dunstan et al., 1997; Ronnemaa, Mattila, Lehtonen, & Kallio, 1986; Schneider et al., 1984; Trovati et al., 1984) and remained unchanged (Allenberg et al., 1988; Rogers et al., 1988; Verity & Ismail, 1989) following training in individuals with Type 2 diabetes. Zierath and Wallberg-Henriksson (1992) have observed that improved glycemic control is more apparent in studies of individuals with Type 2 diabetes younger than 55 years of age. Interpretation of differences in findings following training are complicated by: the use of various assessment methods; disease etiology and severity; training parameters including intensity and duration; pre-training age and levels of glycemic control and physical fitness; adherence to protocol and changes in body composition.

Training enhances whole-body insulin sensitivity ascertained by glucose clearance rates (Bogardus et al., 1984; Devlin, 1992; Krotkiewski et al., 1985; Trovati et al., 1984) and is associated with losses in abdominal fat (Mourier et al., 1997). Specific skeletal muscle improvements have been reported (Dela, 1996; Dela et al., 1995; Martin et al., 1995). Skeletal muscle is the most important tissue for insulin-mediated glucose uptake (DeFronzo, Gunnarsson, Bjorkman, Olsson, & Wahren, 1985). Defects in the insulin-sensitive glucose transporter (GLUT 4) translocation or insulin signaling transduction may contribute to deficiencies in peripheral glucose uptake (Wallberg-Henriksson et al., 1998). Individuals with Type 2 diabetes are not deficient in the muscle GLUT 4 transporters (Choi et al., 1991; Pedersen et al., 1990), but exercise produces their up-regulation and may contribute to a compensatory action (Dela et al., 1994). As an alternative mechanism, the ability of insulin to stimulate muscle blood flow is reduced in individuals with Type 2 diabetes (Laakso, Edelman, Brechtel, & Baron, 1992) and can be improved with training (Dela et al., 1995). The benefits of training on insulin sensitivity are readily lost with de-training (Dela, 1996; Dela et al., 1995).

2.2.2 Other Long-term Effects

2.3.2.1 Cardiovascular fitness

Individuals with Type 2 diabetes have a compromised exercise capacity (Katoh, Hara, Kurusu, Miyaji, & Narutaki, 1996; Regensteiner, Sippel, McFarling, Wolfel, & Hiatt, 1995; Schrier, Estacio, & Jeffers, 1996; Wei et al., 1999) that is predictive of increased risk of coronary artery disease (Rubler, Gerber, Reitano, Chokshi, & Fisher, 1987). This impairment has been associated with microvascular disease, specifically nephropathy and retinopathy, suggesting similar underlying pathogenic mechanisms (Estacio et al., 1998), but not neuropathy (Estacio et al., 1998; Radice et al., 1996). Both lean and obese individuals with Type 2 diabetes respond to training with an increase in cardiorespiratory fitness (Holloszy et al., 1986; Krotkiewski et al., 1985; Lampman & Schteningart, 1991; Verity & Ismail, 1989). Nevertheless, improvements are less than that observed in sedentary nondiabetics (Schneider, Khachadurian, Amorosa, Clemow, & Ruderman, 1992). It has been suggested that intensity recommendations based on age-predicted maximum heart rate may be too high for individuals with Type 2 diabetes (Samaras, Ashwell, Mackintosh, Campbell, & Chisholm, 1996; Schneider et al., 1992).

2.3.2.2 Weight loss

In Canada, 59% of individuals with diabetes aged 35-64 are considered overweight (Health Canada, 1999). American estimates are higher: 65 to 85% (ADA, 1989). Regardless of the method of weight loss, even modest amounts of intentional loss reduces day-long blood glucose levels due to reduced hepatic glucose output, improved beta cell secretory function, and decreased insulin resistance (Henry, Wallace, & Olefsky, 1986). In addition, exercise produces a preferential loss of central body fat stores (Buemann & Tremblay, 1996; Despres, Nadeau, & Bouchard, 1988), a known risk factor for cardiovascular diseases (Buemann & Tremblay, 1996). Exercise has been shown to decrease abdominal fat, especially visceral fat, without changing body weight in two studies of individuals with Type 2 diabetes (Lehmann, Vokac, Niedermann, Agosti, & Spinas, 1995; Mourier et al., 1997).

It has been suggested that it is weight loss, and not exercise training per se, which is primarily responsible for improvements in insulin sensitivity in obese individuals with Type 2 diabetes, especially in older individuals or those with more severe disease (Zierath & Wallberg-Henriksson, 1992). A meta-analysis of weight loss strategies in Type 2 diabetes revealed that dietary strategies alone produced the greatest reductions in weight and improvements in glycemic control in the short-term, but it is as yet unknown whether this is also true for the long-term (Brown, Upchurch, Anding, Winter, & Ramirez, 1996). It must be noted, however, that unintentional weight loss, particularly in the lean individual with Type 2 diabetes (Chaturvedi, Fuller, & The WHO Multinational Study Group, 1995), is not associated with improvements in glycemic control and instead may reflect progression of the underlying disease processes (Shoff, Klein, Moss, Klein, & Cruickshanks, 1998).

Frequency of exercise is one of the most important determinants of weight maintenance (Eriksson, Taimela, & Koivisto, 1997b; Zachwieja, 1996) and exercise may have a preventive effect against weight gain following weight reduction programs (Buemann & Tremblay, 1996; Zachwieja, 1996). Cross-sectional research in Type 2 diabetes indicates that habitual exercisers weigh less than inactive individuals (Summerson, Konen, & Dignan, 1991). Long-term studies of weight maintenance are scarce, especially in populations with Type 2 diabetes (Brown et al., 1996).

Skeletal muscle is largely responsible for the clearance of glucose from the blood (DeFronzo et al., 1985). It has been suggested that the age-related decline of muscle mass observed past the age of 50 may be linked to reduced insulin sensitivity and that strategies for enhancing muscle mass, i.e., resistance training, may warrant additional investigation (Ivy, 1997). While one would then expect individuals with Type 2 diabetes to have a reduced amount of musculature, Svendson and Hassager (1998) reported that muscle mass determined by dual X-ray absorptiometry in women with Type 2 diabetes was not different from expected normal values. Measures of lean body mass are not regularly reported in intervention research in Type 2 diabetes, although this may change with new interest in resistance training interventions, discussed in section 2.2.3.

2.3.2.3 Reduced cardiovascular risk factors

Diabetes increases the risk of macrovascular disease (Stamler, Vaccaro, & Neaton, 1993a). In the 12-year Multiple Risk Factor Intervention Trial (MRFIT), the risk of mortality due to coronary artery disease was three times higher in individuals with diabetes compared with nondiabetic individuals (Stamler, Vaccaro, Neaton, & Wentworth, 1993b). The top three causes of death in persons with diabetes mellitus are myocardial infarction, cerebral vascular disease, and circulatory disorders, respectively (Tan & MacLean, 1995). People aged 35-64 years with diabetes are at six times the risk of heart disease or stroke compared with people without the disease (Health Canada, 1999).

Although death due to coronary artery disease is more common in individuals with poor glycemic control (Moss, Klein, Klein, & Meuer, 1994), glycemic control has not yet been shown to prevent macrovascular complications in Type 2 diabetes (Giugliano, 1996). Cardiovascular risk factors include hypercholesterolemia, hypertension, obesity, and inactivity - factors shown to be more prevalent in adults with diabetes mellitus (Tan & MacLean, 1995). Therefore, it is imperative to examine all possible strategies for managing such risk factors, including physical activity interventions.

Dyslipidemia is characteristic of individuals with Type 2 diabetes and is primarily marked by elevated levels of triglycerides, and reduced levels of high density lipoproteins (HDL) (Brown, 1994). The prevalence of dyslipidemia is double that of non-diabetic populations (Fore, 1995). Dyslipidemia is considered to be one of the strongest risk factors for cardiovascular disease mortality in Type 2 diabetes (Stamler et al., 1993b). Elevated levels of low density lipoprotein (LDL) and very-low density lipoprotein (VLDL) cholesterol have also been observed in individuals with Type 2 diabetes (Gylling & Miettinen, 1997).

Although improved glycemic control has been shown to lower LDL cholesterol (Gaster & Hirsch, 1998), glycemic control alone is not sufficient to improve dyslipidemia (Garber, 1993). Therefore, non-pharmacological management of dyslipidemia includes diet, weight loss, and exercise (Gylling & Miettinen, 1997; Lewis, 1995). Interventions combining exercise and diet to achieve weight reduction in individuals with Type 2 diabetes have demonstrated decreased triglycerides and LDL cholesterol and elevated HDL cholesterol (Gylling & Miettinen, 1997; Lehmann et al., 1995). Loss of body fat mass, rather than exercise per se, is considered to be most likely responsible for these findings (Poirier, Catellier, Tremblay, & Nadeau, 1996). Exercise is singularly one of the most important strategies for increasing HDL, however (Brown, 1994), emphasizing its unique role in reducing cardiovascular risk in this population.

The prevalence of diagnosed hypertension is higher in individuals with diabetes than in nondiabetics (James, Young, Mustard, & Blanchard, 1997). Hypertension is considered a classic risk factor for cardiovascular disease mortality, especially in individuals with Type 2 diabetes (Grossman & Messerli, 1996; Stamler et al., 1993b). Hypertension is associated with abdominal obesity and prospective studies suggest that insulin resistance causes hypertension (Buemann & Tremblay, 1996). The UK Prospective Diabetes Study (UK Prospective Diabetes Study Group, 1998a) has shown that intensive blood pressure control (using pharmaceutical agents) in individuals with Type 2 diabetes results in reduced fatalities due to myocardial infarction and stroke. Exercise reduces blood pressure in hypertensive individuals (Seals, Silverman, Reiling, & Davy, 1997) and individuals with Type 2 diabetes (Lehmann et al., 1995).

2.3.2.4 Reduced long-term microvascular complications of Type 2 diabetes

As stated earlier, microvascular complications of diabetes include retinopathy, nephropathy, and neuropathy. Retinopathy occurs in 63% of insulin-using individuals and in 33% of those who do not use insulin (Tan & MacLean, 1995). According to the 1994/1995 National Population Health Survey in Canada, the prevalence of cataracts and glaucoma is higher in individuals with diabetes than in nondiabetics (James et al., 1997). Glycemic control is strongly associated with the development of retinopathy (Guillausseau et al., 1998).

End-stage renal disease develops in about 5% of individuals with Type 2 diabetes (Tung & Levin, 1988) and improved glycemic control and blood pressure may be important preventive measures in this population (Ritz & Stefanski, 1996). Peripheral neuropathy leads to undetected injury and diabetic foot ulcers, the most common cause of lower extremity amputation (Armstrong & Lavery, 1998).

Clinical guidelines support intensive glycemic control (Meltzer et al., 1998). Long-term intensive glycemic control can delay or prevent the development and progression of microvascular complications in individuals with Type 1 diabetes (Diabetes Control and Complications Trial Research Group, 1993; Reichard et al., 1993) and Type 2 diabetes (Ohkubo et al., 1995; UK Prospective Diabetes Study Group, 1998a).

2.2.3 Resistance Training

The previous sections have dealt with the acute and long-term effects of dynamic exercise on Type 2 diabetes. Considering the pathophysiology of Type 2 diabetes, Soukup and Kovaleski (1993) suggested that resistance training may be a superior training program to standard endurance training. Three recent studies have explored this possibility.

Three months of moderate resistance, high repetition resistance training resulted in improved HbA_{1c} levels independent of changes in body weight in eight moderately obese individuals with Type 2 diabetes (Eriksson et al., 1997a). Although adherence rates were not reported, strength and muscle cross-sectional area increased. There were no changes in cardiorespiratory fitness. Although promising, the very small sample size and the lack of a control group limit conclusions from this study.

Similar improvements in glycemic control were reported in a subsequent study from this same group of researchers (Honkola, Forsen, & Eriksson, 1997). The program was expanded to five months. Thirty-eight individuals with Type 2 diabetes participated, with another 20 serving as control subjects. The resistance training group also showed improvements in total cholesterol, LDL cholesterol and triglycerides. Once again, however, adherence was not reported, limiting the ability to assess acceptability of such a prescription to individuals with Type 2 diabetes.

The most recent study (Ishii, Yamakita, Sato, Tanaka, & Fujii, 1998) reported that 4-6 weeks of moderate intensity, high volume resistance training elicited a 48% in insulin sensitivity, as determined by hyperinsulinemic-euglycemic clamp, in nonobese individuals with Type 2 diabetes. No significant change in glycated hemoglobin was observed, however, the pericd of study was likely too short to adequately examine the effects of resistance training on this variable.

Further confirmative research is necessary, but a review article has recently appeared proposing that the optimal exercise program for individuals with Type 2 diabetes should include resistance training (Eriksson, 1999).

2.3 Physical Activity Epidemiology

Physical activity epidemiology is concerned with physical activity behaviours and disease or other outcomes, the distribution and determinants of physical activity behaviour, and the association between physical activity behaviours and other behaviours (Caspersen, 1989). This section reviews physical activity epidemiology in typically sedentary populations with special reference to Type 2 diabetes.

2.3.1 Physical Activity Epidemiology in Typically Sedentary Populations

Accumulated epidemiological evidence suggests that those individuals who are the most sedentary stand to reap the greatest rewards of even modest increases in activity (Pate et al., 1995). Low income, ethnic minority, older adults, women, and individuals living with disability or chronic illness (including individuals with Type 2 diabetes) are described as typically sedentary (King, Rejeski, & Buchner, 1998; Taylor, Baranowksi, & Young, 1998; US Surgeon General, 1996), yet no consensual definition of sedentarism currently exists (Bernstein, Morabia, & Sloutskis, 1999). *Sedentarism* has been previously classified by reduced: total energy expended; time or distance walked; stair climbing habits; participation in leisure time and/or sports; or performance of vigorous activities (Bernstein et al., 1999).

Intuitively, someone who is sedentary takes part in more inactive behaviours and fewer, and relatively unvaried, active behaviours. For illustration purposes, a graduate student may partake in a number of inactive academic behaviours (e.g., reading, writing, editing, studying) and a number of inactive leisure behaviours (e.g. watching T.V., playing cards, talking on the phone, socializing over meals), yet she cannot be classified as sedentary because she also purposely engages in condensed forms of vigorous activity (e.g., running, aerobics, roller-blading, cycling).

This next section reviews the current understanding of how to measure both inactivity and activity (with specific reference to pedometers). It is necessary for the reader to become familiar with common issues in physical activity epidemiology before it can be reviewed specifically in Type 2 diabetes.

2.3.1.1 Measuring Inactivity

Inactivity is defined as a state in which bodily movement is minimal (Dietz, 1996). Inactive behaviours include: television viewing; reading; computing; sedentary social activities (e.g., card and boardgame playing, talking on the phone); passive commuting; sleeping; meditation; eating; and standing still (e.g., waiting in line) (Ainsworth et al., 1993a; Dietz, 1996).

Of these behaviours, the prevalence of television viewing has received the most attention, especially in relation to obesity in adults (Ching et al., 1996; Fitzgerald, Kriska, Pereira, &

Courten, 1997; Gortmaker, Dietz, & Cheung, 1990; Jeffery & French, 1998; Sidney et al., 1996; Tucker, 1990; Tucker & Bagwell, 1991; Tucker & Friedman, 1989). Television viewing habits have been exclusively determined by self-report in these studies. Increased television viewing has been associated with obesity (Ching et al., 1996; Gortmaker et al., 1990; Jeffery & French, 1998; Sidney et al., 1996; Tucker & Bagwell, 1991; Tucker & Friedman, 1989), reduced physical fitness (Tucker, 1990; Tucker & Friedman, 1989) and physical inactivity (Fitzgerald et al., 1997; Sidney et al., 1996; Tucker & Bagwell, 1991; Tucker & Friedman, 1989). In a prospective analysis of activity level and risk of becoming overweight in over 22,000 male health professionals, Ching et al. (1996) found that higher levels of non-sedentary activity and lower levels of television viewing were independently associated with lower relative risk for becoming overweight within the next two years. To date, no intervention aimed at reducing television viewing has been implemented nor evaluated.

2.3.1.2 Measuring Physical Activity

Historical assessment of physical activity is important to assessing risk and/or determining mechanisms of disease incidence (Ainsworth, Sternfeld, Slattery, Daguise, & Zahm, 1998). Since the ultimate goal of this course of study is intervention, the focus of this section is necessarily on the assessment of current levels (within the last year) of physical activity.

Although seemingly straightforward, measuring physical activity, especially in typically sedentary populations, is fraught with a number of issues. Physical activity can be a complex pattern of behaviour reflecting both the daily demands of unique individual life situations and intentional, or elective, activities. At its most complex levels, dimensions of physical activity volume include frequency, intensity, duration and type. Together, these dimensions are commonly represented as energy expenditure. As Rowlands et al. (1997) point out, however, the terms energy expenditure and physical activity are neither synonymous nor interchangeable. Physical activity is movement; energy expenditure is a reflection of gender, age, and body mass in addition to movement (Bursztain, Elwyn, Askanazi, & Kinney, 1989).

Both direct and indirect methods have been used to classify physical activity levels (Ainsworth et al., 1998). Direct methods include: calorimetry; doubly labeled water; motion sensors; observation; and physical activity records and logs. Indirect methods include: metabolic measures; anthropometric measures; fitness measures (e.g., cardiorespiratory, strength, flexibility); and questionnaires/surveys. The advantages and disadvantages of these various methods have been reviewed in detail elsewhere (Ainsworth et al., 1998; Blair, 1984).

This section will further focus on those measures most useful and practical for determining current physical activity levels in free-living, typically sedentary populations. We will present the methods in order of their frequency of use, or popularity.

2.3.1.2.1 Self-report methods

Although an indirect method, physical activity level is typically assessed in epidemiological studies by self report questionnaires/surveys and diaries/logs due to their practicality, nonreactiveness, and applicability (King & Kriska, 1992). The continued reliance on self-report methods of quantifying physical activity has been described as a measurement conundrum by Dishman (1994a). Despite the inherent inadequacies of self-report methods, self-reported values of physical activity are considered to be reasonably accurate (Blair et al., 1991), but may lack sensitivity to subtle differences in activity in typically sedentary populations. Although not inclusive of all self-report methods of physical activity measurement, an invaluable supplement to the official journal of the ACSM presents over 30 instruments along with their psychometric properties (Kriska & Casperson, 1997). Most available questionnaires assess engagement in performance of vigorous and/or structured, or otherwise planned activities (i.e., sport and exercise). Few attempt to measure either spontaneous or routine light and moderate activities, such as: household chores; family and child care; leisure time activities and occupational activities (Jacobs, Ainsworth, Hartman, & Leon, 1992; Masse et al., 1998).

No questionnaires are currently available to measure intermittent or lower intensity physical activities (Masse et al., 1998). One of the most frequently used instruments (Seven -day Physical Activity Recall; PAR) does not count any activity performed for less than 10 minutes accumulated during the morning, afternoon, or evening (Blair, 1984; Blair et al., 1985). The problems with capturing activity in typically sedentary populations are known and new instruments have been developed in an attempt to meet the need. The Physical Activity Scale for the Elderly (PASE) is one such instrument (Washburn, Smith, Jette, & Janney, 1993). Hays and Clark (1999), however, reported that pilot testing of the PASE with individuals with Type 2 diabetes over 55 years of age was unsuccessful. Most of the respondents reported less than 1 hour of daily activity, less than the floor of the PASE, rendering it useless in this typically sedentary population (Hays & Clark, 1999).

One of the most difficult activities to measure by self-report is walking. Walking is the most widely reported form of physical activity and it appears to be acceptable and accessible even to typically sedentary populations (Siegal, Brackbill, & Health, 1995). The determination of such behaviour is considered essential to the assessment of physical activity in typically sedentary populations (Masse et al., 1998), yet it is one of the least reliably recalled activities (Ainsworth, Leon, Richardson, Jacobs, & Paffenbarger, 1993b; Kriska et al., 1990; Richardson, Leon, Jacobs, Ainsworth, & Serfass, 1993). Subjects also have difficulty comprehending survey questions about walking speed/pace or intensity (relative or absolute) (Masse et al., 1998). Regardless, it remains a primary line of questioning in studies of typically sedentary populations (Hays & Clark, 1999). It has been suggested that the quality of data collection could be improved by the use of face-to-face interviews employing a cognitive model of questioning (Durante & Ainsworth, 1996), prompting subjects to think of the context associated with walking (Masse et al., 1998). The potential improvements in data quality come at considerable staff time and expense, however (Masse et al., 1998).

2.3.1.2.2 Heart rate telemetry

Heart rate telemetry is the electronic recording (using a body-borne instrument) of pulse produced by the repetitive beating of the heart. Heart rate telemetry is used to indirectly determine engagement in physical activity. The rationale for the method is based on the assumption of a linear relationship between heart rate and aerobic capacity. This relationship varies between individuals depending on their endurance capacity, making it prudent to determine individual calibration curves (Haskell, Yee, Evans, & Irby, 1993), a design feature frequently overlooked due to issues of practicality. The HR-$V0_2$ relationship is also affected by external factors including posture, environmental conditions, and emotions (Haskell et al., 1993). At low heart rate levels (characteristic of patterns of activity in sedentary individuals) quantification of energy expenditure is more subject to error (Livingstone et al., 1990).

The value of heart rate telemetry is in assessing moderate to vigorous intensity activities when elevated heart rates are prolonged (Luke, Maki, Barkey, Cooper, & McGee, 1997). For example, athletes regularly used heart rate monitors to gauge and adjust the intensity of their training. It is not considered to be a valid estimate of daily activity, at least in typically sedentary children (Riddoch & Boreham, 1995). The same is likely true for typically sedentary adults since participation in moderate and vigorous exercise is uncommon (Ford & Herman, 1995).

Heart rate telemetry is also cost (due to equipment necessary to record, download, and analyze data), labour (due to the requisite nature of subject instruction and monitoring), and data intensive (especially if recorded minute-by-minute over several days), making it less feasible for larger cross-sectional studies (Rowlands et al., 1997). It is also considered to be intrusive and somewhat uncomfortable for longer term data collection (Wareham, Hennings, Prentice, & Day, 1997) and is therefore unacceptable for intervention studies or practical application.

2.3.1.2.3 Motion sensors

2.3.1.2.3.1 Accelerometers

Motion sensors include accelerometers and pedometers. Accelerometers register electrical charges obtained from the distortion of body-worn piezoelectrical ceramics; the greater the distortion, the greater the voltage evoked (Meijer, Westerterp, Verhoeven, Koper, & ten Hoor, 1991). A number of commercially available accelerometers are now available including the Caltrac (Hemokinetics, Madison WI), the Tritrac (Hemokinetics, Madison WI), and the Computer Science Application (CSA; Computer Science Applications Inc., Shalimar, FL). These instruments range in size and weight and are generally worn at the waist, hip, or lower back. Total energy expenditure is estimated from "activity counts" (raw data indicative of pure movement) by entering such personal data as age, height, weight, and gender. The results are either displayed on a liquid crystal screen or interfaced with a computer for down-loading of data (Westerkerp, 1999). An estimate of energy expenditure due to activity may be calculated by subtracting the resting basal metabolic rate (based on published equations such as the Harris-Benedict equation; (Bursztain et al., 1989) from the accelerometer values (Chen & Sun, 1997).

As mentioned earlier, the terms energy expenditure and physical activity are neither synonymous nor interchangeable (Rowlands et al., 1997). Yet validation studies of motion sensors continue to compare accelerometer values to direct calorimetry and doubly labeled water[1] methods of determination of energy expenditure (Westerkerp, 1999). Using this approach to quantify physical activity, however, it is no wonder that Bray et al. (1994) reported that accelerometer-estimated total energy expenditure was correlated with total energy expenditure measured by direct calorimetry and that the raw movement "activity counts" recorded were not. Another validity study using doubly label also water concluded that "activity counts" are not a meaningful predictor of energy expenditure due to activity (Johnson, Russ, & Goran, 1998).

Comparing energy expenditure due to activity across individuals requires correction for body size (Westerkerp, 1999). A single satisfactory coefficient for adjusting energy expenditure due to activity does not exist, making it difficult to interpret and compare results obtained from individuals of markedly different body sizes (Prentice, Goldberg, Murgatroyd, & Cole, 1996).

Rowlands et al. (1997) suggest that total quantity of movement is likely more important for describing physical activity behaviours than conversion to energy expenditure. Such an unbiased measure would be objective, convenient, and feasible for the study of large populations (Rowlands et al., 1997). Accelerometers are able to provide this measure, but a less expensive

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[1] Since 1982 we have witnessed an expanded use of the doubly labeled water method of determining energy expenditure (Speakman, 1998). Briefly, subjects are followed for 7-21 days after ingesting water labeled with 2 stable isotopes; one eliminated as water and carbon dioxide and the second eliminated only as water. The difference in elimination rates is a reflection of the rate of carbon dioxide production which can be in turn used to calculate energy expenditure with a high degree of accuracy (Speakman, 1998). Drawbacks include its expense and low precision, both of which limit its use to small group studies (Speakman, 1998). Regardless, doubly labeled water in commonly considered the gold standard of energy expenditure measurement in the field of physical activity epidemiology.

and user-friendlier option exists: pedometers. Another advantage that pedometers have over accelerometers is that they may be more feasibly used to intervene as well (Yamanouchi et al., 1995). For program evaluation purposes, it is logical to use the same instrument to both measure and intervene. The potential opportunities and considerations for using pedometers to measure physical activity in typically sedentary populations are discussed next.

2.3.1.2.3.2 Using Pedometers to Measure Physical Activity

Pedometers have been underutilized to date. At least two problems with earlier research have continued to plague the general acceptance of pedometers as a direct measure of physical activity. Firstly, as Bassett et al., (1996) point out, earlier reliability studies were carried out using earlier-generation mechanical pedometers. These gear-driven devices were subject to errors making them unsuitable as precise research instruments. The newer electronic pedometers, although displaying variations in accuracy among brands, are acceptably accurate for recording walking activities, even at slower speeds, in free-living populations (Bassett et al., 1996). The Yamax Digiwalker is currently considered the most accurate (Bassett et al., 1996), likely reflecting higher quality control of manufacturing (maximal permissible rate of miscounting is .3 percent; (Hatano, 1993).

The second reason why pedometers have not achieved respectability among physical activity epidemiologists is due to the criticism of poor reproducibility, or reliability. Basically, earlier research concluded that the instrument was inadequate if repeated measures were inconsistent for a subject walking a set distance. Measurement repeatability in the field was often confused with instrument reliability, however, and the contributions of inconsistent behaviour have been essentially ignored (Tryon, Pinto, & Morrison, 1991). Low test-retest reliability may reflect behavioural instability rather than problems related to the pedometer itself. In a series of experiments, Tryon et al. (1991) showed that pedometers measured walking a set distance with the most certainty in college students, with less certainty in normal children, and with the least certainty in mildly hyperactive children. The point is, accurate instruments do not cause unreliable measurements -- they reveal behavioural inconsistencies that require study in their own right (Tryon et al., 1991).

For example, Lee, Lawler, Panemangalore, and Street (1987) used pedometers to describe, in detail, seasonal variation in physical activity in middle-aged and elderly women (average distance traveled decreased from summer to winter 10.9±8.2 to 8.5±5.4 miles/week, $p<.01$). We know that people significantly underestimate their daily walking distance when questionnaires have been compared with pedometer results (Bassett, Cureton, & Ainsworth, in press). It is therefore unlikely that Lee et al. (1987) would have been able to identify the seasonal effects on physical activity (a mean difference of 2.4 miles accumulated over a week) if a self-report method had been used instead!

The pedometer has been previously considered a suitable method for evaluating physical activity when the predominant activity behaviour is walking (Bassey, Dallosso, Fentem, Irving, & Patrick, 1987; Kashiwazaki, Inaoka, Suzuki, & Kondo, 1986; Saris & Binkhorst, 1977b; Shephard, 1989). Bassey et al. (1987) suggested that the pedometer is likely a more reliable method of physical activity assessment in typically sedentary populations.

A variety of pedometers are commercially available that can quantify steps and estimate distance traveled (typically miles) and/or calories burned. If an estimate of distance or calories is desired, variables such as an individual's stride length, weight and/or age must be entered into the pedometer's memory. The pedometer simply calculates the desired information from the steps counted. This process could introduce additional error. For example, any bodily movement that registers as a pedometer step (for example, shifting weight while seated), would be converted into a distance (Rowlands et al., 1997). Individuals with smaller stride lengths would be penalized despite performing similar activities as someone with a longer stride length (Bassey et al., 1987; Saris & Binkhorst, 1977a). At fast speeds, Bassett et al. (1996) reported that increasing error in estimating distance was due to lengthening of stride rather than miscounting steps. Similarly, reporting energy expenditure in total kilocalories under represents activity undertaken in lighter individuals. For these reasons, Rowlands et al. (1997), recommend that registering movements as simple steps or "counts" reduces bias and is the most appropriate unit of measure using the pedometer.

The most appropriate monitoring frame for determining habitual physical activity is unknown. Gretebeck and Montoye (1980) determined that 5-6 days (including weekend days) of pedometer data were necessary to determine weekly physical activity (with less than 5% error) in a relatively young male sample with varied physical activity habits. Since typically sedentary populations participate in few and relatively unvaried physical activities (Masse et al., 1998), likely a shorter monitoring frame is necessary. Determined one week apart, Sieminski et al. (1997) reported a test-retest intraclass correlation (ICC) of 0.86 for steps/day (averaged over 2 days), in older free-living claudication patients.

Research regarding the validity of pedometers is just beginning to emerge. In cross-sectional studies, daily pedometer values have been positively associated with time spent in leisure time activity (Sequeira, Rickenbach, Wietlisbach, Tullen, & Schutz, 1995; Sieminski et al., 1997) and physical fitness (Ichihara et al., 1996), and negatively associated with age (Sequeira et al., 1995) and percent overweight (Tryon, Goldberg, & Morrison, 1992). Pedometer values have also been shown to distinguish between individuals employed in sedentary and non-sedentary working conditions (Kashiwazaki et al., 1986; Sequeira et al., 1995), as well as within-individual differences in sedentary working and active commuting behaviours (Kashiwazaki et al., 1986).

Only recently have pedometers been used to describe total daily activity in free-living populations (Bassey et al., 1987; Bassey, Patrick, Irving, Blecher, & Fentem, 1983; Cowley, Fullwood, Stainer, & Hampton, 1991; Gardner, Sieminski, & Killewich, 1997; Ichihara et al., 1996; Kashiwazaki et al., 1986; Schmalzried et al., 1998; Sequeira et al., 1995; Tryon et al., 1992; Voorrips, Ravelli, Dongelmans, Deurenberg, & Van Staveren, 1991; Walsh, Charlesworth, Andrews, Hawkins, & Cowley, 1997). Table 1 presents mean values of steps/day reported in these studies. At times it was necessary to calculate steps/day from other data presented in the original articles. These situations are noted in Table 1. Means range from 7,000-13,000 steps/day in healthy younger samples (lower for women than for men), from 6,000-7,000 steps/day in healthy older samples, and from 3,500-5,500 steps/day in individuals living with disabilities and chronic diseases.

Dr. Andrea Dunn of the Cooper Aerobic Research Institute indicated (personal communication) that the lifestyle intervention conducted in Project Active (Dunn et al., 1999) used pedometers as self-monitoring tools. Unfortunately, comments on the use of this tool (or actual values) were not reported in their publication. In a recent review of lifestyle physical activity interventions, however, Dunn, Anderson, and Jakicic (1998) suggest that pedometers (or "step counters") be considered to assess the effectiveness of such interventions.

Only four published physical activity interventions have used pedometers to evaluate program effectiveness (Bassey et al., 1983; Fogelholm, Kukkonen-Harjula, & Oja, 1998; Meshkinpour et al., 1998; Yamanouchi et al., 1995). The nature of each intervention, sample characteristics, and pedometer results are displayed in Table 2. Two of these studies did not describe baseline values (Fogelholm et al., 1998; Yamanouchi et al., 1995). Bassey et al. (1983) demonstrated a significant post-intervention increase in steps/day in a sample that was already relatively active (judging by baseline steps/day). Meshkinpour et al. (1998) also reported an improvement in pedometer results presented as distance traveled (insufficient information was provided to calculate steps/day). Only two of these studies reported using pedometers to monitor activity during the intervention (Meshkinpour et al., 1998; Yamanouchi et al., 1995). Neither comment on the experience nor present day to day pedometer values.

We do not know the optimal number of steps/day necessary to produce health benefits. Literature out of Japan has recommended a goal of 10,000 steps/day for all individuals (Hatano, 1993) and individuals with Type 2 diabetes (Yamanouchi et al., 1995). There is no evidence to support this recommendation and it suggests a threshold value, below which no benefits result. We do not know this. Although it does seem to be a reasonable estimate of younger and/or otherwise healthy individuals (Bassey et al., 1987; Kashiwazaki et al., 1986) it may be too lofty a goal for typically sedentary populations, evident from the descriptive values presented in Table 1 (e.g., (Cowley et al., 1991; Gardner et al., 1997; Schmalzried et al., 1998; Walsh et al., 1997).

Pedometers are ideally suited to evaluating lifestyle interventions aimed at meeting recommendations to accumulate 30 minutes of moderate physical activity on most, if not all, days of the week (US Surgeon General, 1996). A simple timed walk (with a pedometer) could be used to determine steps taken in 30 minutes of continuous walking. Post-intervention values could then be compared with baseline values, and assessed with regards to meeting the public health recommendations.

In summary, pedometers represent a low cost, direct and accurate measure of physical activity in typically sedentary populations. Unlike self-reported physical activity, pedometers are not subject to recall or social desirability biases. They also place a relatively low burden on subjects. Pedometers are capable of quantifying small incremental increases in physical activity, especially walking behaviour, as a continuous variable and do not suffer from floor or ceiling effects. More widespread use of pedometers in typically sedentary populations will allow us to examine more closely factors related to increased physical activity, specifically walking behaviours. They are especially promising for use in Type 2 diabetic populations, characterized as typically sedentary.

2.3.2 Physical Activity Epidemiology in Individuals with Type 2 Diabetes

We now turn to a discussion of physical activity epidemiology in the population of interest. This section should not be confused with the earlier discussion (in Chapter 1) of risk factors for the development of Type 2 diabetes. The focus here will be on: 1) the distribution and determinants of physical activity behaviour in individuals with Type 2 diabetes; 2) the association between physical activity behaviours and diabetes complications; and 3) the association between physical activity behaviours and other behaviours (Caspersen, 1989). The reader is forewarned that the literature to date in this area is limited and disjointed.

The prevalence of sedentarism appears to be quite high in persons with diabetes mellitus. Hays and Clark (1999) recently reported that almost 55% of a sample of 260 individuals with Type 2 diabetes reported zero minutes of weekly physical activity in response to questions about walking behaviours. Disability is also prevalent and may contribute to the high estimation of inactivity in this population (Tan & MacLean, 1995).

A review of survey data from the 1990 United States National Health Interview Survey, found that 52% percent of individuals with diabetes reported activity limitations as compared with only 17% of nondiabetics (Ford & Herman, 1995). Sixty-six percent of individuals with diabetes reported not participating in regular leisure-time physical activity, compared with 59% of nondiabetics, although this difference was negated when activity limitations were considered. These distinct populations did not differ on mean number of bouts of exercise, average number of minutes per bout of exercise, or mean total weekly hours of exercise (Ford & Herman, 1995). Differences were noted, however, in activity choices. People with diabetes were more likely to engage in walking and less likely to engage in: jogging; aerobics; dancing; calisthenics; golf; tennis; bicycling; yoga; weight lifting; basketball; soccer; and skiing than were people without diabetes (Ford & Herman, 1995).

Levels of self-reported activity have not been previously associated with long-term glycemic control ascertained by measures of glycosylated hemoglobin (HbA_{1c}) in cross-sectional studies of individuals with Type 2 diabetes (Blaum, Velez, Hiss, & Halter, 1997; Selam, Casassus, Bruzzo, Leroy, & Slama, 1992). One of these studies relied on a global self-care instrument to ascertain self-reported engagement in exercise behaviour (Blaum et al., 1997). The other study showed a tendency for improved control that was not significant in this small clinical population (Selam et al., 1992). The authors suggested that the lack of observed effect might reflect a disinterest in exercise in-patients with satisfactory control and/or a vain attempt of those with poor control.

Subgroup analysis of individuals with Type 2 diabetes within a large cross-sectional multicultural study showed a positive relationship between overall physical activity (including both vigorous as well as nonvigorous activities) and insulin sensitivity determined by an intravenous glucose tolerance test (Mayer-Davis et al., 1998).

Engagement in exercise behaviour in individuals with Type 2 diabetes has been associated with some lifestyle behaviours (increased seatbelt use and dental checkups) but not with others such as blood glucose monitoring, obtaining periodic health examinations, smoking, and alcohol consumption (Summerson et al., 1991).

2.4 Behavioural Perspective

2.4.1 Introduction

It is worth mentioning again that although the terms physical activity and exercise are not interchangeable. The behavioural literature has displayed an increased preference for the term physical activity, although the majority of research to date (both in general and in diabetic populations) has been conducted on structured and class-based exercise programming. In this field at least, adoption and adherence pertains to purposeful or intentional physical activity undertaken to improve health and/or fitness. This generally excludes physical activity undertaken in the course of commuting, working, chores, errands, and the like.

Therefore, within the context of purposeful or intentional physical activity (including exercise) we will discuss: 1) the promising applicable behavioural theories and models; and, 2) the determinants of adoption and adherence. At the end of this section we critique published interventions conducted in the population of interest to date.

2.4.2 Behavioural Theories and Models

A number of behavioural theories and models have guided physical activity promotion efforts (King et al., 1992; Marcus, King, Clark, Pinto, & Bock, 1996). The most promising approaches include applications of social cognitive theory, especially in regards to its central component, self-efficacy (Dzewaltowski, 1994; Marcus et al., 1996), and, more recently, augmented with the transtheoretical or the "stages of change" approach (Buxton, Wyse, & Mercer, 1996; Marcus & Simkin, 1994). Social cognitive theory proposes that personal and environmental factors, as well as factors related to the desired behavioural change, interact and influence each other and can be manipulated accordingly (Bandura, 1986). It will be discussed more fully later in section 2.4.3.1.2.

The transtheoretical model, or stages of readiness to change (specifically increase), integrates: 1) reported behaviours; and, 2) intentions to maintain or alter habitual behaviour (Marcus et al., 1996). Briefly, the stages are precontemplation (no intention to change), contemplation (considering change), preparation (making small changes), action (actively engaged in changing behaviour), and maintenance (continued successful behaviour change) (Marcus & Simkin, 1994). Although intention is considered an important determinant for some behaviours, the relationship between intention and exercise behaviour is much weaker (Courneya & McAuley, 1993). For individuals with Type 2 diabetes, behaviour change is not always the result of incremental stepwise shifts in intention; radical changes may result from epiphanies or “conversion experiences” (O'Connor, Crabtree, & Yanoshik, 1997).

The stages serve as a framework for identifying individual readiness and for tailoring cognitive and behavioural modification approaches (Buxton et al., 1996). The concepts of self-efficacy and decisional balance contribute to stage-based interventions and are plausible outcomes of interest (Marcus et al., 1996). Since the majority of individuals with Type 2 diabetes believe they should get more exercise (Searle & Ready, 1991), according to readiness theory strategies we should move beyond education and awareness raising and instead focus on behavioural processes necessary for action. No physical activity interventions for individuals with Type 2 diabetes structured around self-efficacy and/or readiness theories have been evaluated thus far, despite their promise (Clark, 1997).

2.4.3 Determinants of Physical Activity (Exercise) Adoption and Adherence

Despite the multiple benefits of increased physical activity (specifically exercise as discussed in section 2.2) adherence to exercise recommendations is remarkably low compared to other aspects of diabetes management (e.g., blood glucose monitoring, diet, medication) (Jenny, 1986; Kamiya et al., 1995; Kravitz et al., 1993). Additionally, long-term attrition is common a common feature of structured exercise programs (Schneider et al., 1984; Schneider et al., 1992; Skarfors et al., 1987). Sallis and Hovell (1990) suggest there are four distinct phases to increasing physical activity: adoption, maintenance or adherence, relapse, and resumption. *Adoption*, or getting started, is the subject of a recent review article (Dunn, 1996). The focus of the adoption literature to date is on the determinants of purposeful physical activity adoption, or specifically, characteristics of those who participate versus those who do not. A great deal more research has been conducted in general populations than in diabetic populations.

Maintenance, or *adherence* refers to continued behaviour. The study of adherence to purposeful physical activity is hampered by the lack of a common approach to quantifying levels of adherence (McNabb, 1997), compounded with the measurement issues discussed thoroughly in section 2.3.1.2. *Relapse* suggests a temporary discontinuation of previously established physical activity behaviours. Attrition, or determination of rate of dropout, is one way of describing relapse, or conversely, non-adherence. This alone is unacceptable. For example, Schneider et al. (1992) reported the results of 1-year follow-up interviews with 100 previously sedentary individuals with Type 2 diabetes who had dropped out of a structured exercise program within three months. At follow-up, 73 previously labeled dropouts reported that they engaged in some form of physical activity at least twice a week, suggesting that their brief commitment had succeeded in facilitating subsequent activity. This is an important finding that had escaped conventional definitions of non-adherence.

Narrowly defined, however, as discontinued attendance or participation, individuals with Type 2 diabetes more frequently relapse in their exercise behaviour compared with nondiabetics (Krug et al., 1991). This relapse is associated with increased guilt and feelings of being out of control and of failure (Krug et al., 1991). Individuals with Type 2 diabetes tend to believe that having relapsed makes subsequent attempts more difficult, further thwarting attempts to exercise regularly (Krug et al., 1991). Exercise relapse rates of 75-80% have been reported (Krug et al., 1991; Swift, Armstrong, Beerman, Campbell, & Pond-Smith, 1995). Schneider et al. (1992) suggested that high levels of anxiety associated with recent diagnosis or stressful life events may contribute to a tendency for early attrition from a structured exercise program. We know very little about *resumption*, or return to previously established physical activity behaviours in the general population or in individuals with Type 2 diabetes (Sallis & Hovell, 1990).

This next section will focus on the determinants of physical activity participation (both adoption and adherence), specifically engagement in exercise behaviours. The determinants have been reviewed previously (primarily studies in non-clinical populations) and are generally categorized as personal, environmental, and program factors (Dishman, 1989; Dishman, Sallis, & Orenstein, 1985; King, 1997; King et al., 1992). The same organizational structure will be used here but the emphasis will be placed factors applicable to individuals with Type 2 diabetes. Where possible, a distinction will be made between the separate behaviours of adoption and adherence.

2.4.3.1 Personal Factors

Demographic variables associated with reduced activity levels in the general population include: increasing age; female gender; obesity; lower socioeconomic status and education levels; employment in blue-collar occupations; and at times, ethnicity (King et al., 1992). The relationship between smoking and reduced activity is more modest (King, 1997). Age is an independent risk factor for Type 2 diabetes (Katz & Lowenthal, 1994) and a correlate of physical inactivity in individuals with Type 2 diabetes (Hays & Clark, 1999). Females with Type 2 diabetes are more likely to engage in no form of physical activity, compared with males (Hays & Clark, 1999). Individuals with Type 2 diabetes are frequently obese (ADA, 1989). Socioeconomic, cultural, and genetic factors likely contribute to elevated levels of diabetes documented in people of color (Haffner, 1998), although lower education is correlated with inactivity in individuals with Type 2 diabetes regardless of race or ethnicity (Hays & Clark, 1999). Considering this clustering of demographic variables, it is not surprising that diabetic populations are characteristically under-active (Ford & Herman, 1995; Hays & Clark, 1999; Tan & MacLean, 1995).

2.4.3.1.1 Knowledge, beliefs, attitudes

Knowledge of, and beliefs in, the health benefits of exercise participation are more related to adoption than adherence in the general population (King, 1997). Cross-sectional analysis shows no association between physical activity knowledge and behaviour in individuals with Type 2 diabetes (Hays & Clark, 1999), and, Falkenberg et al. (1986) reported that an improvement in diabetes-related knowledge was not accompanied by a change in self-reported activity habits. A decrease in perceived health and fitness was associated with an increased belief in the benefits of exercise in a population-based sample (Uitenbroek, 1993). A similar relationship may not be the case in populations with chronic diseases (Oldridge & Spencer, 1985); a prospective study found that individuals with diabetes, hypertension, obesity, and/or elevated serum cholesterol decreased their exercise behaviour over 15 years compared with peers without disease or disease-related factors (Ferrini, Edelstein, & Barret-Connor, 1994). Beliefs about the benefits of increased physical activity (exercise) are lower and perceived barriers to becoming more active are higher in individuals with Type 2 diabetes compared with other aspects of self-management (Glasgow, Hampson, Strycker, & Ruggiero, 1997; Pham, Fortin, & Thibadudeau, 1996; Polly, 1992; Swift et al., 1995).

Although the majority (84%) of individuals with Type 2 diabetes believe that they should get more exercise (Searle & Ready, 1991), perceived barriers include: physical discomfort; health problems; lack of energy; fear of hypoglycemia; other peoples' actions and chance happenings; being too overweight; and a lack of family support (Krug et al., 1991; Searle & Ready, 1991; Swift et al., 1995; Wilson et al., 1989). An external locus of control, or the extent to which an individual perceives life events to be outside of his/her own control, has been associated with lower levels of physical activity in free-living general populations (Dishman & Steinhardt, 1990) and in populations with Type 2 diabetes (Gregg, Kriska, Narayan, & Knowler, 1996; Swift et al., 1995).

2.4.3.1.2 Self-efficacy and outcome expectations

Self-efficacy, a central construct of social cognitive learning theory (Bandura, 1986; Bandura, 1997), has been consistently associated with physical activity in a wide variety of populations and settings (King, 1997; King et al., 1992). Self-efficacy is an individual's confidence in his/her ability to perform the task/behaviour. It is both behaviour- and situation-specific (Bandura, 1986). At least one study suggests that perceived self-efficacy is a strong predictor of self-care practices in individuals with Type 2 diabetes, including exercise behaviours (Skelly, Marshall, Haughey, Davis, & Dunford, 1995).

There is evidence suggesting that positive outcome expectations (e.g., beliefs in the benefits of exercise), when combined with high exercise self-efficacy, strengthen the ability to predict activity adherence in general populations (Clark, Patrick, Grembowski, & Durham, 1995; McAuley & Rudolph, 1995) and may be particularly important to adopting activity behaviour (Clark, 1996). Individuals with Type 2 diabetes perceive regular exercise to be beneficial but extremely difficult to achieve, however (Glasgow et al., 1989).

2.4.3.2 Environmental Factors

Both physical and social environmental factors can affect adoption and adherence behaviours. Physical environmental factors include access to facilities, weather, and cost (Dishman, 1994b). Social environmental factors include social support and influences, obligations and disruptions (Dishman, 1989). Although the use of environmental prompts, cues, and incentives have received some attention (King, 1997; King et al., 1992), by far the most significant environmental factor studied to date affecting exercise and physical activity adherence behaviours is social support (Hillsdon & Thorogood, 1996; King, 1997).

2.4.3.2.1 Social support

Social support is considered an important influencing factor in physical activity adoption and adherence, especially concerning class-based programs (Clark, 1996; Courneya & McAuley, 1995) where regular social interactions may evolve into feelings of camaraderie or fellowship (Carron, Widmeyer, & Brawley, 1988; Schneider, 1996; Spink & Carron, 1992). Within class-based programs, strategies to increase group cohesion and social support have resulted in improved adherence (Spink & Carron, 1992; Spink & Carron, 1993; Wankel, Yardley, & Graham, 1985).

Although individuals can successfully be taught to seek social support for structured exercise from a variety of sources (Wankel et al., 1985), very little is known about the role social support plays in individually-planned purposeful physical activity pursued outside supervised settings (King, 1997). Similar to the general population, lack of social support for exercise is considered a barrier by individuals with Type 2 diabetes (Pham et al., 1996; Swift et al., 1995). Sources of support include: spouses; children; other family members; peers; instructors/interveners; and health care professionals (Chogahara, Cousins, & Wankel, 1998). The latter group, in the case of diabetes, includes: the physician; diabetes educator; nurse; dietitian and others. Preferred sources of support may vary during phases of exercise adoption and long-term adherence (Oka, King, & Young, 1995). For example, Schneider et al. (1992) reported that participation of a nondiabetic spouse was a strong predictor of continued adherence (after three months) to a structured exercise program.

Professional contact (in the form in person or via telephone) appears to be one of the most promising behavioural strategies for improving adherence (Hillsdon & Thorogood, 1996; Hillsdon, Thorogood, Anstiss, & Morris, 1995). There is limited evidence, however, that physical activity promotion principally through primary care physicians is efficacious or has lasting effects (Eaton & Menard, 1998). Schneider et al. (1992) reported that individuals with Type 2 diabetes who participated in a structured exercise program primarily because of physician referral were unlikely to adhere.

Social influences can have either a positive or a negative effect on exercise behaviour (Chogahara et al., 1998). Negative social influences are unsupportive, inhibitive, or resistive to change (Chogahara et al., 1998). The relationship between diabetes control and social support may be different for men and women (Heitzmann & Kaplan, 1984; Kaplan & Hartwell, 1987). Perceived social support was associated with improved diabetes control in women only, suggesting that men may receive more support for nonadherence to self-care (Heitzmann & Kaplan, 1984). On the other hand, a large social support network may interfere with self-care behaviours in women, but not in men (Kaplan & Hartwell, 1987).

2.4.3.3 Program Factors

Complex and restrictive medical screening prior to commencing regular exercise (ADA, 1999) may also present a barrier to increased activity. These guidelines continue to be recommended despite the fact that no cost-effectiveness studies have been conducted (Samaras et al., 1996) and that serious complications related to exercise are rare (Eriksson, 1999; Schneider et al., 1992). These same guidelines give no direction for individuals with Type 2 diabetes with known cardiovascular disease despite its prevalence (Samaras et al., 1996). The lack of direction for this specific subgroup suggests that they are not to exercise, despite the fact that exercise is a recognized and important treatment in cardiac rehabilitation (Dafoe & Huston, 1997). Such stringent screening recommendations, coupled with non-existent guidelines for those who may benefit the most, may serve only to deter individuals with Type 2 diabetes from engaging in this health-promoting behaviour.

Other barriers, real or perceived, to participation in purposeful physical activity and/or exercise include program factors such as accessibility and convenience, scheduling, transportation, and/or costs and equipment (King, 1997; King et al., 1992). Research into barriers to exercise has focused on perceptions of abstainers or dropouts (Dunn, 1996), so whether such factors are truly reasons for poor adherence or are excuses for sedentary behaviour is uncertain (King & Kriska, 1992). Swift et al. (1995) reported that both exercisers and non-exercisers with Type 2 diabetes were equally able to identify barriers to exercise, suggesting the former group differed only in their ability to overcome these barriers.

Type of physical activity is another important factor to consider. Physical activity interventions have shifted away from structured and supervised fitness classes to home-based and lifestyle interventions incorporating cognitive and behavioural theories (Dunn, 1996). Home-based programs compared directly with formal programs have shown higher adherence rates (King, Haskell, Taylor, Kraemer, & DeBusk, 1991). Multiple short bouts of exercise taken during the day, compared with a single long bout, elicit similar improvements in cardiorespiratory fitness but display improved exercise adherence in women (Jakicic, Wing, Butler, & Robertson, 1995) and no difference in men (DeBusk, Stenestrand, Sheehan, & Haskell, 1990). Reviews of randomised controlled trials of physical activity promotion strategies in apparently healthy populations report that those trials most successful in increasing physical activity are home-based, of moderate intensity, involve walking, and include regular follow-up contact (Hillsdon & Thorogood, 1996; Hillsdon et al., 1995).

As previously mentioned, adherence to recommendations to exercise is remarkably low compared with other aspects of diabetes management (Jenny, 1986; Kamiya et al., 1995; Kravitz et al., 1993) and long-term attrition is common in structured exercise programs (Ecclestone, Myers, & Paterson, 1998; Schneider et al., 1984; Schneider et al., 1992; Skarfors et al., 1987). Tracking analysis of data collected from our own structured exercise programs tracked over a 3-year period showed that participants in a diabetes exercise program had the highest dropout rate of 75% compared with a low of 27% for a similar program for individuals with osteoporosis (Ecclestone et al., 1998). Similarly, a retrospective report of a 10-year experience with an exercise program for individuals with Type 2 diabetes indicated acceptable adherence up to three months in the program, but poor long-term adherence (Schneider et al., 1992).

Less structured forms of exercise are apparently more appealing to individuals with Type 2 diabetes. For example, Searle and Ready (1991) found that individuals with Type 2 diabetes participate less often in organized programs (8%) compared with individually-pursued (or informal) exercise (37%), and interest in joining a structured exercise program is low (37%) despite the fact that over 85% believe they should get more exercise (Searle & Ready, 1991).

"Lifestyle" physical activity interventions (Wing, 1989), reflective of public health recommendations (US Surgeon General, 1996), have been studied in representative samples of sedentary adults and obese children (Dunn et al., 1998). To date, only two studies have been conducted with individuals with Type 2 diabetes (Walker, Piers, Putt, Jones, & O'Dea, 1999; Yamanouchi et al., 1995). Both of these studies (described in detail in section 2.4.5) reported excellent short-term adherence to physical activity recommendations.

2.4.4 Intervention Strategies

Supervised, class-based exercise interventions in general populations have successfully used such strategies as reinforcement, stimulus control, self-monitoring, goal setting and contracting, feedback, and relapse prevention techniques (King, 1997; King et al., 1992). Although less well studied, the use of environmental prompts, incentives, and contests have successfully been used to increase daily lifestyle activity and active commuting behaviours (King, 1997). Marcus (1996) has summarized the "critical components" of successful interventions in general populations: 1) enhancing perceived benefits; 2) enhancing self-efficacy; 3) increasing intentions to exercise; 4) increasing enjoyment of activity; 5) enhancing social support; and, 6) including moderate intensity activity.

To date, application of such strategies to increase physical activity in Type 2 diabetes has received limited empirical attention. A pilot study examining the impact of motivational interviewing on a variety of self-care behaviours, found improvements in some aspects of diabetes care compared with a control condition, but not specifically exercise behaviour (Smith, Heckemeyer, Kratt, & Mason, 1997). Similar results were reported from a telephone-delivered intervention (Kirkman et al., 1994). Self-monitoring increased reported exercise behaviour in one study for 4 to 6 weeks following diabetes education (Bielamowicz, Miller, Elkins, & Ladewig, 1995). The use of activity diaries is common practice in physical activity interventions, both as a motivator and as a means of determining adherence to recommendations.

2.4.5 Physical Activity Interventions in Type 2 Diabetes

Earlier we presented the physiological responses to long-term exercise training studies. This section differs in that we limit our discussion to interventions that have purposely attempted to document an increase in physical activity, itself a worthwhile and independent outcome.

Questionnaires, activity diaries, attendance, and/or pedometers ascertained physical activity participation in these studies. Multiple intervention trials are excluded from this analysis (Barnard et al., 1994; Domenech, Assad, Mazzei, Kronsbein, & Galiardino, 1995; Hanefeld et al., 1991; Lucas et al., 1987; Sonnaville et al., 1997; Wing & Anglin, 1996). Although these interventions show improvement in a number of parameters, including glycemic control, the effects of increased physical activity cannot be separated.

Surprisingly, despite the well known benefits of increased activity for this population, very few intervention studies in Type 2 diabetes have attempted to document increases in physical activity or otherwise examine physical activity as an independent outcome of interest (Hartwell, Kaplan, & Wallace, 1986; Lehmann et al., 1995; Ligtenberg, Hoekstra, Bol, Zonderland, & Erkelens, 1997; Raz, Hauser, & Bursztyn, 1994; Samaras et al., 1997; Vanninen, Uusitupa, Siitonent, Laitinen, & Lansimies, 1992; Walker et al., 1999; Wing et al., 1988; Yamanouchi et al., 1995). See Table 3. The majority of interventions are class-based (Hartwell et al., 1986; Lehmann et al., 1995; Ligtenberg et al., 1997; Raz et al., 1994; Samaras et al., 1997; Wing et al., 1988); one is a physician-driven education intervention delivering a structured exercise message (Vanninen et al., 1992), and two others most closely reflect public health recommendations to increase activity on a daily basis (Walker et al., 1999; Yamanouchi et al., 1995). In general, adherence to physical activity is often determined from self-reported diaries, or described as attendance at scheduled classes, and is not often collaborated with more objective measures of fitness improvements. A single exception has used pedometers to gauge volume of walking undertaken (Yamanouchi et al., 1995). At times physical activity is not ascertained in control conditions or at baseline, although such measures are important to drawing firm conclusions about behaviour change. Physical activity questionnaires are most frequently used to determine increased energy expenditure resulting from an intervention, although the problems with such self-report methods are well known (Ainsworth et al., 1998). Participants are often self-selected and therefore eager to participate, a factor that may artificially enhance adherence and may make generalization to more typical diabetic populations difficult. Interventions are relatively brief, although there is a growing body of studies conducting follow-up evaluations, important to assessing long-term adherence. Reasons for attrition are rarely reported and none of these studies have attempted to describe the experiences of dropouts.

These interventions vary widely in their recommended frequency, intensity, duration, and type of activity, complicating comparative analysis. The studies that have used behavioural strategies to increase activity (Hartwell et al., 1986; Samaras et al., 1997; Wing et al., 1988) and/or manipulate social support to improve adherence (Lehmann et al., 1995), present limited descriptions of the interventions or the effectiveness of such efforts.

The two studies of most interest (Walker et al., 1999; Yamanouchi et al., 1995) will be described in detail. Yamanouchi et al. (1995) conducted a clinical trial to evaluate the effects of daily walking combined with diet therapy and diet therapy alone on insulin sensitivity in obese individuals with Type 2 diabetes. Twenty-four subjects were assigned to one of the two groups that were matched for age, gender, and body mass. The diet and physical activity group was instructed to walk at least 10,000 steps/day as monitored by a pedometer, whereas the diet only group was instructed to maintain a regular routine. During the 6-8 week study, the diet and physical activity group averaged 19,200±2,100 steps/day and the diet only group averaged 4,500±290 steps/day.

Body weight decreased significantly in both groups. However, the diet and physical activity group experienced a greater body weight loss than the diet only group. Before training, there was no difference between the groups in regards to basal blood glucose or insulin levels. After training, blood glucose levels were slightly but significantly reduced in both groups while blood insulin levels were reduced significantly in the diet and physical activity group only. A euglycemic clamp procedure was performed before and after the study. Glucose infusion rate and glucose metabolic clearance rates were used to determine insulin sensitivity. After training, there was no difference in either of these parameters in the diet only group. Both parameters increased significantly in the diet and physical activity group, indicating an improvement in insulin sensitivity. An analysis of variance demonstrated significant interaction effects indicating the important contribution of increased physical activity. A general linear models multiple regression procedure was used to evaluate the correlations between changes in body weight and the mean steps per day taken on the change in glucose clearance rate. They reported an effect of walking, but not of the changes in body weight.

The authors concluded that physical activity, specifically walking, can be an effective means of weight loss and improved insulin sensitivity in individuals with Type 2 diabetes. The strengths of this study include its direct applicability to this population and its ease of prescription. It appears that a distance goal, reflecting a total volume of physical activity, may be an effective means of prescribing a lifestyle activity. In fact, it is very interesting to note the dramatic differences between the prescribed number of steps in the diet and physical activity group and the actual number taken. Apparently, the distance prescription was very acceptable to this population when a target distance was prescribed. Because the euglycemic clamp procedure was used, a confident measure of insulin sensitivity was insured (Bergman, Finegood, & Ader, 1985).

The length of the intervention was described as 6-8 weeks, but it is unknown how this varied between individuals or the possible differential effects achieved with longer duration. The long-term effects of this brief intervention on habitual activity are also important missing components of this study. Finally, it is unfortunate that measures of glycemic control were not included in this study.

In the most recent study (Walker et al., 1999), participants were instructed to walk 60 minutes at their own pace 5 days each week for 12 weeks. Adherence was determined from self-recorded logs; subjects were asked to record starting and ending times of their daily walking sessions. Reported walking during the 12-week intervention averaged 4.1±1.6 hours/week, taken in 6.0±2.4 walks. Again no baseline data was presented, so it is difficult to determine change in physical activity. Changes in measures of physical fitness, body composition, lipid profile, and glycemic control, however, provide additional evidence that physical activity was increased.

2.5 Summary

Since the acute glycemic benefits of exercise are transient, future research needs to establish whether or not physical activity or exercise results in an average daily lower blood glucose and whether or not this can contribute to improving long-term glycemic control as measured by HbA_{1c} levels. If this is possible, we need to then explore the volume of physical activity or exercise necessary to achieve these results and its optimal timing throughout the day. It may be possible to achieve similar average daily blood glucose levels with either single long bouts or multiple short bouts if the amount of daily energy expenditure is held constant. Before we can rule out the importance of a threshold intensity of exercise, however, we need to characterize the glucose response to low-intensity lifestyle activity (i.e., walking), a study that has not yet been performed.

Since insulin resistance is the primary source of hyperglycemia in individuals with Type 2 diabetes, a prudent approach is to conduct similar studies using accepted measures of insulin sensitivity. To date, only the effects of single long bouts of exercise (typically on a stationary bicycle) at 50-80% of VO_2 *max* have been studied. Since walking is the preferred activity choice for this population, the effects of typical intensities of walking on insulin sensitivity need to be described. The acute and long-term effects of resistance training on insulin sensitivity in this population are promising and need to be explored further, including a direct comparison with dynamic exercise. It may be that a combination of resistance and dynamic training can elicit optimal improvements in glycemic control and insulin sensitivity.

The mechanism behind the consistently observed lower cardiorespiratory capacity in this population is still unknown. The impact of this on the validity of using age-predicted maximal heart rates to prescribe exercise is an important question. Perceived overexertion could thwart future attempts to exercise and maximal exercise increases, rather than reduces, hyperglycemia in this population (Kjaer et al., 1990). Intensity of exercise is related to improvements in cardiorespiratory fitness, an important predictor of cardiovascular disease, so once again, recommendations for exercise intensity cannot be disregarded.

Long-term benefits are related to adherence to physical activity behaviour. It is important to capture the activity experiences of everyone involved in the study, including abstainers, dropouts, treatment, and control subjects. Attendance at scheduled classes does not capture changes in overall activity levels. Self-report questionnaires and activity diaries may be insensitive to subtle changes in lifestyle activities. More promising objective measures include motion sensors (accelerometers and pedometers). Pedometers are also promising as immediate personal feedback instruments, similar to the use of glucose meters in this population. Their use needs to be explored further.

Strategies that incorporate opportunities for performance accomplishment, vicarious experience, verbal persuasion, and reinterpretation of physiological states need to be systematically evaluated to determine their effects on self-efficacy, outcome expectations, and subsequent physical activity and exercise behaviours in this population. Interventions based on these strategies need to report their effects on these social cognitive and behavioural variables.

Social support is a mostly untapped strategy for increasing adherence behaviours. Regular professional contact needs to be combined with strategies for optimizing personal social networks more effectively. Efforts to increase social support should also include strategies to increase group cohesion in class-based interventions. Once again, it is imperative that the relative success of such strategies be evaluated.

Finally, we need to move beyond comparing exercise interventions with no-exercise control groups and instead compare the efficacy, feasibility, and effectiveness of interventions designed to increase physical activity. It is time to develop, evaluate, and share model programs that have the potential to impart the multiple benefits of an active lifestyle to this susceptible population.

Chapter 3: Evaluation of Stage of Change for Exercise Behaviour as an Indicator of Physical Activity

3.1 Introduction

As mentioned in Chapter 1, this study was carried out in a predominantly non-diabetic population as a means of both pilot testing various instruments of physical activity measurement and determining the best methods of classifying sedentarism. The specific purpose of this study is to evaluate the ability of the stages of change for exercise behaviour, (a popular method of describing intention to exercise) to discriminate between persons at three levels of physical activity (inactive, irregularly active, and regularly active). Stages of change classification is compared to: a past-year self-report of occupational and leisure physical activity; a self-recorded 3-day activity log; and concurrent objective measures using heart rate monitoring and a pedometer. A number of the issues of physical activity epidemiology are confronted and addressed in this empirical examination.

Marcus and colleagues (Marcus, Selby, Niaura, & Rossi, 1992b) applied the transtheoretical model, (also referred to as stages of change) based upon the work of Prochaska and DiClemente (1984) in addictive behaviours, to exercise behaviour. This model describes the cognitive and behavioural processes necessary to move from one transitional stage to another until a change is successfully attained. The stages, described earlier but repeated here for ease of readability, are precontemplation (no intention to change), contemplation (considering change), preparation (making small changes), action (actively engaged in changing behaviour), and maintenance (continued successful behaviour change) (Marcus & Simkin, 1994). A sixth stage, relapse (discontinued behaviour), was included in the original scale (Marcus et al., 1992b).

Scales integrate reported physical activity involvement, specifically exercise, with intentions to maintain or alter this behaviour (Cardinal, 1995; Marcus et al., 1996) . A Canadian version has replaced the term exercise with physical activity (Canadian Society for Exercise Physiology, 1998). Irregardless of intention to change, with respect to reported behaviour, all scales suggest that individuals in precontemplation, contemplation, or relapse are similarly inactive (e.g., I am not physically active, I do not exercise, etc.), individuals in preparation are irregularly active (e.g., I am physically active once in a while, I exercise once in a while but not regularly, etc.), and those in action or maintenance are similarly regularly active (e.g., I am currently physically active, I participate in regular physical activity, I exercise regularly, etc.).

The stages of change have been previously collapsed into this 3-stage activity model and validated based on self-reported participation in vigorous leisure time activity (Marcus & Simkin, 1993). The 3-stage activity model has also been used as a basis for comparing the physical activity behaviours of 431 women; based on self-identified stage of change, researchers concluded that 39% were sedentary, 34% were irregularly active, and 27% were active (Marcus, Pinto, Simkin, Qudrain, & Taylor, 1994).

Both published (Marcus et al., 1992a) and unpublished physical activity interventions have used stages of change scales as an outcome measure of increased physical activity. However, the validity of the stages of change with respect to physical activity behaviours has relied exclusively upon self-report methods (Buxton et al., 1996; Cardinal, 1995; Marcus & Simkin, 1993; Wyse, Mercer, Ashford, Buston, & Gleeson, 1995), focused on the performance of vigorous sports and leisure time activities (Masse et al., 1998). Thus, it is not surprising that clear differentiation between stages in these validity studies was only evident with analysis of such activities (Buxton et al., 1996).

As discussed thoroughly in section 2.3, physical activity includes spontaneous or routine light and moderate activities, such as: household chores; family and child care; leisure time activities and occupational activities (Jacobs et al., 1992; Masse et al., 1998). Additionally, the recall of walking behaviours by self-report questionnaires is notoriously inaccurate (Ainsworth et al., 1993b; Bassett et al., in press; Kriska et al., 1990; Richardson et al., 1993), although walking is a frequently reported choice of physical activity (Siegal et al., 1995). Despite an earlier review calling for the validation of the stages of change using objective measures of physical activity that can overcome the limitation of self-report methods (Marcus & Simkin, 1994), no such study has been reported yet. Therefore, we embarked on such a study.

3.2 Methods

3.2.1 Subjects

The Office of Human Research and Animal Care, University of Waterloo approved this project. A convenience sample of 50 university staff members (10 males, 40 females; mean age 48.3 ±SD6.0, 95% CI 46.6-50.0) were recruited through two waves of interdepartmental flyers. Responding subjects were scheduled for an assessment in a staggered fashion over 4 months (necessary due to equipment availability). Assessments took approximately 40 minutes and included measurements of height, weight, and average gait length and the completion of a number of questionnaires, described below. Subjects were then given detailed instruction, practice, and feedback on self-monitoring of physical activity using an activity log, a heart rate monitor, and a pedometer. Subjects were instructed to complete self-monitoring of physical activity on three consecutive days, including one weekend day. A simple set of written instructions was provided to facilitate data collection and a contact telephone number to call if any problems occurred. Research assistant (J.H.) initiated telephone calls were placed on the first or second day of data collection to each of the subjects at their place of work to assure proper functioning of all equipment.

As soon as possible after the collection period, subjects returned equipment and activity logs. At this time, data collection problems were identified and corrected as far as was possible. Subjects were asked to give feedback on the process, including their experiences with the various indicators of physical activity.

Height and weight were assessed without footwear, according to the Canadian Physical Activity and Fitness Appraisal protocols (Canadian Society for Exercise Physiology, 1998), for the purposes of calculating body mass index (BMI;weight in kg/height in meters^2). Gait was counted every time the lead foot touched down over 10 meters (an extra three meters were allowed for acceleration and de-acceleration) determined over three trials at the subject's self-selected normal walking pace.

Subject characteristics were collected by questionnaire (Appendix A). Stage of change was obtained from a self-administered questionnaire (Canadian Society for Exercise Physiology, 1998) completed during the assessment. Self-reported stages of change were collapsed into the 3-stage activity model described previously.

3.2.2 Physical activity recall

The Modifiable Activity Questionnaire (MAQ) (Kriska et al., 1990) was used to assess past-year occupational and leisure activities. In a Pima Indian population, test-retest reliability (Spearman's rank order correlations) for past-year occupation was 0.88 for 21-36 year olds and 0.88 for past-year leisure for 37-59 year olds (Kriska et al., 1990). The MAQ has been validated with both accelerometers (Kriska et al., 1990) and doubly labeled water (Schulz, Harper, Smith, Kriska, & Ravussin, 1994). Reported hours/week for all leisure activities over the year can be weighted by estimated metabolic cost of the activity and expressed as MET-hours/week. Credit is only given for occupational activities of moderate (e.g., carrying light loads, continuous walking, heavy cleaning) or heavy intensities (e.g., heavy construction, active farming, wood hauling). The developers suggest leisure data be analyzed both with and without walking for exercise, due to unreliability of self-report for this particular activity (Kriska et al., 1990). Differences in leisure activity between reported occupational task categories were examined. Dr. Andrea Kriska (University of Pittsburg) provided telephone training in the administration of the MAQ.

3.2.3 Current activity

3.2.3.1 Activity log

The Bouchard 3-Day Physical Activity Log (Bouchard et al., 1983) is comprised of three 24-hour records divided into 96 15-minute intervals. For each interval, subjects were asked to enter a number corresponding to an accompanying list of activities that best described their own activity during that time. There are 9 categories of activities representing increasing energy expenditures, ranging from low to high intensity. For example, all activities engaged in while lying down (watching television, reading, napping, etc.) are coded as 1. Activities performed while sitting are coded as 2. Light activities performed while standing, with little other movement (cooking, dusting, shaving, etc.) are coded as 3, etc. The design of this activity log provides opportunity to tabulate and examine time recorded in specific categories, such as 2 (sitting or inactive behaviours) and 6-9 (moderate-high intensity activity behaviours). Intraclass correlation (ICC) of test-retest reliability conducted on 61 adults was 0.97 (Bouchard et al., 1983). The activity log has been associated with submaximal determinations of aerobic capacity (ICC=0.31), and percent body fat (ICC=-0.13) (Bouchard et al., 1983).

3.2.3.2 Heart rate monitoring

The heart rate monitor used in this study (Polar Accurex Plus, Kempele, Finland) consisted of a plastic band containing two electrodes, one on each side of the chest, and an adjustable elastic band to ensure a snug fit. A transmitter in the band communicates with a wristwatch to display data. The watch was programmed to store heart rate data at 15-minute intervals for 66 hours. Subjects wore the equipment only during their waking hours. Heart rate data was downloaded immediately to the accompanying Polar data analysis software. Data was described as the average heart rate (HR). Energy expenditure was calculated from the mean daily HR using a prediction equation for group data (kcal/min=-4.4.05+0.084HR)(Kalkwarf, Haas, Belko, Roach, & Roe, 1989) and then multiplied by the number of minutes heart rate was recorded. To account for energy expenditure during time not worn, the energy cost of lying down was added (0.26kcal/kg/15min) (Bouchard et al., 1983). A similar approach to estimating energy expenditure from heart rate monitoring was considered useful for determination of group energy expenditure, but not for individuals (Kalkwarf et al., 1989). For comparison purposes (with the activity log), the estimated energy expenditure was divided by body weight to arrive at kcal/kg/day.

3.2.3.3 Pedometer

A commercially available and inexpensive electronic pedometer (Thermore Fitness Control, Orlando, Florida; approximately $10.00 CAN) was used in this study. Although there are variations in accuracy among brands, electronic pedometers appear to be acceptably accurate for measuring walking behaviours (Bassett et al., 1996). The reliability and validity of pedometers in the assessment of physical activity in free-living populations was covered in detail in Chapter 2. Subjects were instructed to record their pedometer values at the end of each day on the activity log and reset the pedometer each morning. Pedometer data were treated in two ways: 1) as raw counts (steps), and, 2) multiplied by average step length in meters to describe distance covered in kilometers. Average step length =average gait length/2. Energy expenditure in kcal/kg/day based only on the pedometer data was not calculated because it required too many fallible assumptions about the speed and duration of walking through out the day.

3.2.4 Inactivity

Measures of inactivity were determined from: 1) a question (in the MAQ) about time spent television viewing; 2) a question (in the MAQ) about hours sitting on the job ; and, 3) daily average time spent in category 2 (sitting) tabulated from the activity log.

3.2.5 Analyses

Data are presented as means ±SD, 95% CIs. Chi^2 analyses were used to examine between-group differences in categorical variables. A paired-sample *t* test was used to examine differences in MAQ total activity with and without inclusion of walking for exercise. An independent sample *t* test was used to examine differences in MAQ leisure activity in different occupational groups identified (low or moderate intensity occupation requirements). Ranked with respect to gait length, tertiles were compared for differences in distance traveled. Differences in measures between each of the 3-stage activity model categories were assessed using a one-way ANOVA. Post-hoc *t* tests were then used to investigate any significant findings.

Data were analyzed using SPSS Version 8.0 Statistical Software; $p<.05$ was considered to be statistically significant.

3.3 Results

3.3.1 Sample characteristics

According to the 3-stage activity model based on stage of change, 13, or 26% of the sample were inactive (2 precontemplation, 6 contemplation, 5 relapse), 15, or 30% were irregularly inactive (preparation), and 22, or 44% were regularly active (8 action, 14 maintenance). With regards to age there was no difference between the inactive (46.5±5.2, CI=43.4-49.6), irregularly active (47.0±5.6, CI=43.9-50.1) and regularly active groups (50.2±6.3, CI=47.4-53.0). Subjects' BMI averaged 27.8±6.0, CI=26.1-29.6kg/m^2. There was no difference in BMI between the inactive (28.3±5.9, CI=24.7-31.8), irregularly active (29.8±8.1, CI=25.3-34.3), and, the regularly active (26.3±4.5, CI=24.2-28.3) groups.

For the total sample, three (6%) had some high school, nine (18%) had a high school diploma, 12 (24%) had some post-secondary schooling, and 26 (52%) were college or university graduates. Three (6%) perceived their health as fair, 36 (72%) perceived it as good, and 11(22%) perceived their health as excellent. Two (4%) were current smokers, one (2%) was an occasional smoker, 30 (60%) had never smoked, and the remaining 17 (34%) were former smokers, having quit 11.1±6.2, CI=7.9-14.3 years previously. One (2%) perceived themselves as underweight, 24 (48%) perceived themselves at the right weight, and the remaining 25 (50%) perceived themselves to be overweight. The most commonly diagnosed chronic conditions reported were back problems (15, or 30%), allergies (11, or 22%), high cholesterol (4, or 8%), and high blood pressure (3, or 6% of the sample). There was no difference between activity groups with regards to education, perceived health, smoking status, perceived weight status, or any of the chronic conditions reported.

3.3.2 Physical activity recall

The most frequently reported leisure activities captured by the MAQ were walking (35, or 70%), gardening (31, or 62%), cycling (20, or 40%), aerobics (14, or 28%), dancing (8, or 16%), jogging (8, or 16%), and swimming (7, or 14%). Those in the regularly active group were more likely to report engaging in aerobics (10, or 20% vs. 3, or 6% for the irregularly active and 1, or 2% for the inactive groups; Chi^2=6.46, *p*=.013). There were no other apparent differences between activity groups with regards to frequency of these reported leisure activities or cell sizes were too small to adequately approximate the Chi^2 (Moore & McCabe, 1993; Ostle & Mensing, 1975).

For the total sample, there was a significant difference between total activity hours/week with walking for exercise included for analysis, then excluded (8.7±9.3, CI=6.1-11.4 vs. 7.3±9.7, CI=4.5-10.0, *p*<.001). The same conclusion was held true when activity was weighted for metabolic cost and described as MET-hours/week (35.8±37.3, CI=25.2-46.4 vs. 30.7±38.6, CI=19.7-41.7; *p*<.001) Therefore analysis for between group differences was conducted using both approaches (Kriska et al., 1990).

The sample reported predominantly low intensity occupational tasks; only 11 subjects reported moderate intensity tasks. No one reported heavy intensity occupational tasks. There was no difference between activity groups (inactive=2, irregularly activity=5, regularly active=4; Chi^2=1.6-46, *p*=.440) with regards to frequency of reported moderate occupational tasks). There was no difference in leisure activity by reported occupational groups as presented in Table 4.

The results of the between group comparison for the MAQ are presented in Table 5. There was no difference in MAQ total hours/week or MET-hours/week between groups. The regularly active group reported significantly more hours/week and MET-hours/week of leisure activity than the inactive group. Analyzed with walking for exercise included, the regularly active group reported more hours/week and MET-hours/week of leisure activity than the irregularly active. When walking for exercise was excluded from the analysis, leisure hours/week were not different, but leisure MET-hours/week were significantly different between the irregularly active and regularly active groups.

3.3.3 Current activity

There were no differences between groups with any indicator of current activity collected by the log, heart rate monitor, or pedometer (see Table 6) and there was no difference between groups for any of the indicators of inactivity explored (see Table 7). There was no correlation between energy expenditure derived from the activity log or from heart rate monitoring ($r=-.186$, $p=.285$). The intraclass correlation coefficient was -0.37. Details are of all measures are described below.

3.3.3.1 Activity log

Complete data was collected from the activity log. Subjects generally reported that the log was easy to complete, although they believed some of the activities they performed were not represented in the categories presented. Subjects typically completed the logs by updating them 1-3 times during the day, rather than recording each 15-minute block as it happened. For the whole sample, energy expenditure calculated from the activity log averaged 44.8±5.3, CI=43.3-

46.3 kcal/kg/day. Time spent in moderate-high intensity activities (categories 6-9) averaged 1.0±0.9, CI=0.7-1.2 hours for the sample.

3.3.3.2 Heart rate monitoring

Due to equipment failure and/or subject error, heart rate data was lost on 15 (30%) subjects. The most frequently reported problems were that the monitor cut out regularly around electrical machinery (automobiles, vacuum, cell phone, hair dryer), and that it was uncomfortable to wear (itchy, caused a rash, tight). Subjects wore the heart rate monitors an average of 13.6±1.0, CI=12.8-14.4 hours/day. For the sample, daily heart rates averaged 84.3±8.3, CI=81.4-87.1 beats per minute. Energy expenditure calculated from heart rate data averaged 41.2±10.5, CI=37.6-44.9 kcal/kg/day.

3.3.3.3 Pedometer

Pedometer data was lost on two (4%) subjects due to equipment failure. Subjects reported problems with the pedometer falling off. All pedometers were recovered, however, and subjects indicated that pedometer values were not substantially altered due to falling off. Subjects averaged 12,254±6,254, CI=11,437-15,071 steps/day. Walking gait averaged 1.4±0.1, CI=1.3-1.4 meters and calculated daily distance traveled averaged 9.0±4.2, CI=7.8-10.3 kilometers.

3.3.4 Inactivity

3.4 Discussion

As previously reported (Kriska et al., 1990), we found that there was a significant difference for both total and leisure activity when walking for exercise was first included, then excluded from the analysis. Although this could be interpreted as an indicator of the popularity of walking for exercise, reliability of the MAQ is improved with its removal (Kriska et al., 1990).

The MAQ was originally developed for use in describing physical activity levels in Pima Indians (Kriska et al., 1993). The incidence of Type 2 diabetes in the Pima Indians is among the highest in the world (Knowler, Saad, Pettitt, Nelson, & Bennett, 1993). Physical activity, assessed by the MAQ, has been associated with obesity and glucose intolerance in the Pimas (Kriska et al., 1993). We would therefore expect our relatively healthy middle-aged sample to fare well comparatively to this population on the same measure of physical activity. MAQ values for hours/week of leisure activity observed in our study for both the inactive and irregularly active groups are similar to those reported for a male Pima Indian sample aged 37-51 years (2.5 hours/week), and higher than values found for female Pimas (0.5 hours/week) (Kriska et al., 1993). Hours/week of leisure activity in the regularly active group are similar to a younger sample of male Pimas (6 hours/week; 21-36 years) (Kriska et al., 1993). We are therefore confident in the values we obtained from the MAQ.

Although 11 subjects reported performing moderate intensity tasks as part of their occupational requirements, these subjects were evenly distributed across the three activity categories, and did not differ in leisure activity participation from the rest of the sample. Therefore, it was considered appropriate to retain this subgroup in the analysis.

The 3-stage activity model has previously been validated against participation in vigorous leisure time physical activity behaviour (Marcus & Simkin, 1993) using a commonly employed measure of physical activity: the 7-day physical activity recall questionnaire (Blair et al., 1985). A difference was not evident between groups for participation in moderate intensity activities (Marcus & Simkin, 1993). Using a different self-report method, we similarly showed that individuals classified as regularly active category (using the same 3-stage activity model) reported more frequent participation in leisure activities (walking for exercise considered) and for longer duration and greater intensity compared with individuals in the inactive and irregularly active categories. There was no difference between the inactive or irregularly active categories for any self-reported physical activity variable, however. Adjusting for walking for exercise negated any difference in hours/week of leisure activity between the irregularly active and the regularly active groups. This suggests that, outside of walking behaviours, the two groups participate in a similar duration of leisure time activity, but that the activity intensity preference of the regularly active group is higher.

The MAQ suffers from the same limitations as other questionnaires intended to assess physical activity: non-work related activity is focused on the performance of vigorous and structured, or otherwise planned activities. There is no consideration for recording activities related to household chores or family and child care, although such activities are considered important contributors to total daily physical activity (Jacobs et al., 1992; Masse et al., 1998).

Adjusting for body weight, published mean values of energy expenditure for similarly aged adults calculated from the activity log are similar to those we observed (45kcal/kg/day) (Bouchard et al., 1983). Although mean time in moderate-high intensity activities appears to increase over the three activity categories, the variance is high and the 95% CIs overlap dramatically, providing additional evidence that the three divisions under examination are not different with respect to self-recorded activity.

The activity log is considered a direct measure of current activity (Ainsworth et al., 1998). However, because subjects in this study reported that they completed the log 1-3 times during the day, rather than simultaneously with activity behaviours, errors in the underlying cognitive processes likely occurred (Durante & Ainsworth, 1996) when attempting to recall activity details for each of the 96 cells in the log. This self-recording method also required that subjects compare their own activities with an accompanying list of activity categories, and then extrapolate for activities performed that were not listed. Some subjects noted that the list of activities provided were predominantly male-oriented and did not include examples of typical office work activities, household chores, or child care activities. The log method also required the subject to select the most representative activity performed for 15 minutes, assuming a continuity of daily activity that does not necessarily exist.

The accuracy of energy expenditure calculated from heart rate is improved with individual calibration curves accounting for interindividual differences in the relationship between HR and aerobic capacity (Haskell et al., 1993). This can be both cost and time prohibitive, however, in larger studies. Thus, the approach taken herein using a group-based prediction equation is justified given the study's purpose. Energy expenditure calculated from heart rate monitoring was similar to published mean values for 19-27 year old women (adjusted for body weight: 44kcal/kg/day) (Kalkwarf et al., 1989). Although Kalkwarf et al. published both a single line prediction equation and a segmented line (divided at 120bpm) to account for imperfect HR-VO_2 relationships at lower intensities, the single line approach was selected for this study because it came closer to reference energy expenditure computed from energy intake and stores (Kalkwarf et al., 1989). Another approach to discriminating physical activity levels was considered, namely, time spent in a zone considered beneficial to cardiorespiratory training (ACSM, 1998). A minute-by-minute data collection process would be necessary, however, to accurately represent this indicator of engagement in vigorous physical activity. In order to capture three consecutive days of heart rate data, confidence in equipment electronic memory limited our collection to 15-minute intervals.

Another limitation of our approach to heart rate monitoring was in accounting for energy expended while the monitor was not worn, or otherwise not collecting data. We assumed that subjects were at rest, however, missing data could also be due to equipment malfunction, a problem that others have also documented (Kalkwarf et al., 1989; Wareham et al., 1997). Wareham et al. (1997), describe a computer program that they have developed to smooth aberrant data readings collected during minute-by-minute heart rate recordings, necessary for analyzing this data-intensive approach. Unfortunately, because we did not have subjects record the time at which the monitor was put on or removed, we do not have a full understanding of the missing data. This is an important procedure to consider in subsequent studies using heart rate monitoring.

Although similar mean values of energy expenditure were derived from the activity log and through heart rate monitoring, these values were not correlated with each other. As described previously, the one method is a self-record subsequently translated to energy expenditure using a limited list of reference activities, and the second method translates monitored physiological responses to energy expenditure based on a flawed assumption of HR-VO_2 linearity. It is not surprising that they are not correlated given the limitations of both approaches.

Although the pedometer does not pick up intensity of activity, most individuals infrequently engage in vigorous activities (Blair, 1984). Pedometer data, however, is considered an accurate indicator of walking behaviours (Bassett et al., in press; Bassey et al., 1987; Kashiwazaki et al., 1986; Saris & Binkhorst, 1977a). The pedometer values we collected are similar to values reported previously for clerical workers (10,571±4,336) (Kashiwazaki et al., 1986), assembly workers (11, 294±2,336) (Kashiwazaki et al., 1986), and medical school workers (10,793±3,553) (Bassey et al., 1987). We collected a broad range of pedometer values for the sample (evident from the 95% CIs reported), improving our confidence that we were able to recruit subjects representative of a broad spectrum of physical activity, specifically with regards to walking behaviours

Concern about the effect of gait length on calculated distance travel has been previously expressed (Bassey et al., 1987; Rowlands et al., 1997; Saris & Binkhorst, 1977a). We found, however, that analysis of pedometer data with respect to tertiles of gait length showed no difference in calculated distance traveled. Regardless, describing pedometer data as distance traveled remains essentially flawed as even shifts in body weight would be converted to distance traveled.

The most frequently reported problem with the pedometers was that they sometimes fell off, especially in individuals with greater abdominal adiposity and during bending movements. In a personal communication, Dr. Barbara Ainsworth (School of Public Health, University of South Carolina) has shared similar problems with another brand of pedometer. Manufacturers should improve commercially available pedometers by providing a more secure hinge attachment.

None of the indicators of inactivity differed between activity categories. As Dietz (1996) points out however, inactivity is not necessarily the opposite of activity; individuals who engage in vigorous and structured exercise may also report high amounts of television viewing or occupational sitting. Alternatively, the self-report and recording methods used to assess inactivity in this study may suffer from similar problems of recalling low and moderate intensity physical activities, that is, both the frequency of sedentary activities and their relative lack of salience (Ainsworth et al., 1998; Durante & Ainsworth, 1996).

In conclusion, regardless of its performance in assessing intention, as a mode of classifying physical activity behaviours, stages of change serves as little more than a crude indicator of participation in vigorous physical activities. Stages of change should not be used to make conclusions about interindividual differences in recalled physical activity levels other than participation in vigorous leisure activities. Stage of change is not a good indicator of either self-recorded for two methods of objectively determined current physical activity level.

We could therefore not use stages of change to identify potential subjects for subject recruitment to our planned intervention study. The next chapter describes a study that was not part of the original proposed research, but was deemed necessary after documenting a suprisingly high level of reported physical activity in a sample of individuals with Type 2 diabetes. What follows is a detailed examination of subsequent attempts at screening for sedentarism in individuals with Type 2 diabetes.

Chapter 4: Screening for Sedentarism in Individuals with Type 2 Diabetes

4.1 Introduction

Subject recruitment is a critical first step in the evaluation of physical activity interventions. Researchers set *a priori* inclusion and exclusion criteria to control for factors that may otherwise affect the outcome of interest. In order to more easily document increases in physical activity behaviours, it is necessary to begin with truly inactive, or sedentary individuals. There are two sets of guidelines currently available to assist with screening for inactivity: 1) the ACSM recommendations (1998) to engage in continuous rhythmic activity at 60-90% age predicted heart rate, for 20-60 minutes, 3-5 days a week; nor, 2) the public health recommendations to accumulate 30 minutes or more of moderate activity on most, if not all, days of the week (Pate et al., 1995).

Both these guidelines were used to screen out overly active individuals during the recruitment process used in preparation for the evaluation of a novel daily physical activity intervention (the focus of this thesis and described in detail in Chapter 5). Eighty-six individuals, recently diagnosed (within the previous year) with Type 2 diabetes (age 40-60 years, BMI 28-35, treated by diet or oral hypoglycemic medication), were identified through a manual search of patient files held at a diabetes education centre. Physician permission was obtained to contact each patient regarding the study. During a telephone conversation, chart information was verified. Further, subjects were asked two global questions related to physical activity: 1) Do you currently attend any formal exercise or activity programs?, and 2) Do you currently accumulate 30 minutes or more of moderate physical activity (equivalent to brisk walking) on more than two days of the week? The latter question was intended to screen out individuals who potentially met both guidelines described above, at least for frequency of participation.

Surprisingly, a high number of subjects were screened out due to high reported activity levels, primarily based on the latter question. Only two (2%) individuals were excluded due to involvement in formal exercise programs; while 44 (51%) were excluded due to self-reported individual activity levels higher than the public health messages. We found that less than 25% (20) of our sample were reportedly sedentary according to our questions (Pate et al., 1995). In comparision, secondary data analysis conducted by Ford and Herman (1995) has indicated that 66% of individuals with Type 2 diabetes reported that they did not exercise or play sports regularly. Hays and Clark (1999) recently reported that almost 55% of a sample of 260 individuals with Type 2 diabetes reported 0 minutes of weekly physical activity in response to questions about walking behaviours.

It may be that simply asking individuals if they meet the public health recommendations yields a false result shaped by social bias (Masse et al., 1998). The use of a valid and reliable physical activity assessment tool, such as the frequently used 7-day physical activity recall questionnaire (PAR) (Blair et al., 1985), may provide a clearer picture of the prevalence of inactivity in this population. Data collected in this manner can be analyzed for energy expenditure and also categorized with respect to attainment of physical activity guidelines. Such an approach in an obese population (of a similar age to our study population) revealed that 62% were sedentary, 21% met the public health recommendations, and 17% met the traditional exercise-fitness recommendations (Weyer, Linkeschowa, Heise, Giesen, & Spraul, 1998).

Alternatively, all of the members of the sample we were attempting to recruit had received standard diabetes education since their diagnosis, including messages to exercise regularly. It may be possible, given the recency of diagnosis, that the individuals contacted were indeed more active than what is portrayed in the literature examining physical activity in Type 2 diabetes. Some individuals with Type 2 diabetes may have sudden conversion experiences and dramatically alter their behaviours (O'Connor et al., 1997).

The aim of this study was to re-contact by telephone members of a population of individuals with Type 2 diabetes who had previously screened out of our physical activity intervention because of their self-reported activity levels. We wished to systematically examine current activity levels in two manners: 1) with regards to energy expenditure, and, 2) with regards to attainment of either the traditional fitness guidelines (ACSM, 1998) or the new, broader daily activity recommendations (Pate et al., 1995). A secondary purpose was to explore the perceived effect, it any, diagnosis and/or diabetes education may have increasing physical activity levels.

4.2 Methods

We re-contacted the 46 individuals, who had been excluded from our intervention study due to self-reported physical activity levels. A single interviewer (G.B., fourth year kinesiology student) was trained to conduct the structured telephone interviews. Evening telephone calls were placed over a 3-month period (avoiding seasonal holidays) beginning two weeks after the original physical activity screening. In the case of no contact, messages were left on answering machines (if available) indicating the caller's purpose and an approximate time of another follow-up call. Follow-up attempts were terminated after approximately 4-6 calls with no contact.

To compare the level of physical activity (classified according to the two general guidelines described in section 4.1), we chose to administer the 7-day Physical Activity Recall

(PAR) (Blair et al., 1985) rather than the MAQ (Kriska et al., 1990), described in previous Chapter 3. Due to the recency of diagnosis in this population and the possible effect it may have already had on their physical activity behaviours within the last year, the MAQ (a 12-month recall) was not considered to be suitable for the purposes of this study. The PAR has been subjected to extensive reliability testing and shows good repeatability (Kriska & Casperson, 1997). It has been validated against self-report methods, direct observation (in children), heart rate monitoring, and accelerometers (Kriska & Casperson, 1997). Briefly, it is a semi-structured interview that estimates total energy expenditure from an individual's recalled duration of sleeping, and duration and intensity of activities for the 7 days prior to the interview. Credit is only given for activities of moderate intensity or higher (similar to how interviewee feels when they are walking at a normal pace, or walking faster, or running). To be scored, an activity must total at least 10 minutes in duration for that portion of the day being considered (morning, afternoon, evening).

Time spent in light activities for each day is calculated as the difference between 24 hours and time spent in all other recalled categories. Recalled time in activity is multiplied by a corresponding MET value and then summed to obtain energy expenditure values in kcal/kg/day. One MET is the metabolic equivalent of sleeping, time in light activity is 1.5 METs, moderate activites are 4 METs, hard activities are 6 METs, and very hard activies are 10 METs. A tape-recording of typical interviews was obtained from Dr. James F. Sallis (Department of Psychology, San Diego State University, San Diego, California) and used in interviewer training. A published telephone script was used to guide interviews (Kriska & Casperson, 1997).

Based on the information provided, participants were categorized according to: 1) Blair's (1984) recommended energy expenditure divisions (active≥40kcal/kg/day, inactive≥35-

<40kcal/kg/day, or very inactive <35kcal/kg/day); and, 2) a structure used previously in a similar study with obese individuals (Weyer et al., 1998):

1. TR group (traditional recommendation): participating in vigorous activities (6-10 METs) for ≥20 minutes at least 3 times a week, irrespective of the time engaged in moderate activities.
2. NR group (new recommendation): participation in moderate physical activities (3-6 MET) for ≥30 minutes at least 5 times per week, without fulfilling the traditional recommendation.
3. SED group (sedentary): meeting neither the traditional, nor the new recommendations.

Subjects were also asked two simple questions regarding: 1) their current physical activity levels (more, less, or about the same) compared to pre-diagnosis with Type 2 diabetes; and, 2) whether or not they attributed any increased physical activity to their diabetes education.

Energy expenditure is presented as mean±SD, 95%CI. All categorical data are presented as frequencies. McNemar's exact test for correlated proportions (Rosner, 1990) was used to compare the frequency of sedentarism determined by the two methods of analysis.

4.3 Results

Thirty-six (78%) of the original sample (46) were re-contacted. Thirty-one (67%) of eligible individuals completed the survey and 5 (11%) declined participation. No contact was made with 8 (17%) individuals despite repeated attempts. Two (4%) others had either moved or changed their telephone number. Telephone call surveys lasted between approximately 20 and 45 minutes.

Calculated energy expenditure for the sample averaged 34.4±6.7, CI=32.0-36.8kcal/kg/day. According to the divisions suggested by Blair (1984), five, or 16% of the sample were active, one, or 3% was inactive, and 25, or 81% were very inactive. Adding the inactive and very inactive categories together, 82% were classified as sedentary. In comparison, categorized according to attainment of physical activity guidelines, nine (29%) met the traditional fitness recommendations, nine (29%) met the public health recommendations, and 13 (42%) individuals were classified as sedentary. Thus the likelihood of being classified as sedentary was significantly higher using the energy expenditure divisions ($p<.01$). Thirteen (42%) were classified as sedentary by both methods of analysis. Of the 13 classified as sedentary only by the energy expenditure categories, 7 (54%) met the traditional recommendations and 6 (46%) met the public health recommendations.

Fourteen (45%) said their current physical activity levels were higher than pre-diagnosis, 14 (45%) said they were about the same, while three people (10%) said they were less active now compared with pre-diagnosis. Of the 14 identifying improved activity levels, 79% believed that their diabetes education had helped.

4.4 Discussion

The primary limitation of this analysis was the difficulty re-contacting the sample by telephone. Contact rate was 78%, but only 67% agreed to complete the survey. Our conclusions of sedentarism are necessarily limited to the sub-sample re-contacted.

The PAR is focused on the performance of moderate and vigorous activities performed for at least an accumulated 10 minutes during each portion of the day, presuming a continuity of activity performance that is not typical of many daily activities (e.g. household chores and family or child care). Performance of light and/or sporadic activities is estimated by subtraction for the entire time frame after adjusting for the more easily recalled activities and time spent sleeping. People with diabetes are less likely to participate in vigorous leisure activities (Ford & Herman, 1995). Therefore, despite its popularity (i.e., frequency of use) the PAR may underestimate energy expenditure in this population due to an inherent insensitivity to physical activity preferences.

Different analytical procedures using the same data resulted in disparate conclusions about prevalence of sedentarism. Only one instrument was used in this study to collect physical activity. The prevalence of sedentarism doubled (84% vs. 42%) when the sample was classified according to energy expenditure guidelines compared with attainment of physical activity guidelines. The fact that the former approach identified more sedentarism was at first surprising. We therefore worked through the PAR's calculations with a imaginary subject who minimally met the ACSM guidelines (ACSM, 1998). If this phantom slept eight hours a night and participated in only three hours of hard activity (6 METs) during the week (on different days), their calculated energy expenditure would be 33.9kcal/kg/day and they would be classified as very inactive (Blair, 1984), regardless of the fact that they would have met the requirements of the traditional fitness recommendation. In fact, we found that seven individuals falling below still met the energy expenditure threshold met the traditional recommendations while six met the public health recommendations. The PAR threshold value of below 35kcal/kg/day has been used as inclusion criteria to recruit "sedentary" individuals for physical activity interventions (Dunn et al., 1997).

Weyer et al. (1998) also categorized a sample of obese individuals with respect to attainment of physical activity guidelines (using the PAR as a data collection tool only). They reported 62% sedentarism, compared with 42% determined herein. All of our subjects had been diagnosed with diabetes within the last year and also had attended standard diabetes education that includes a message to increase physical activity, specifically exercise. Forty-five percent of our sample did indicate that they had increased their activity since diagnosis, and most of these individuals (79%) attributed their change to their education. The sample that Weyer et al. (1998) studied did not have similar incentives to become more active.

In summary, the evidence indicates global questions reflective of physical activity guidelines are inadequate for classifying sedentarism. Recruitment efficiency in this typically sedentary population may be improved using a more objective approach (capable of ascertaining variations with regards to accumulated light and/or sporadic activities). Pedometers may be a better choice to quantify physical activity as a continuous variable. For instance, pedometer values could be compared with normative data (collected during the course of the study described in Chapter 3) to recruit those who lay below a selected threshold value suggestive of inactivity (justifiably, the 25 percentile). We are currently evaluating such an approach at our centre and the preliminary findings are very encouraging.

We now present the focus of this thesis: the development, implementation, and evaluation of a novel physical activity intervention for individuals with Type 2 diabetes.

Chapter 5: Development, Implementation, and Evaluation of a Daily Activity Intervention for Individuals with Type 2 Diabetes

This chapter describes the development, implementation, and evaluation of a novel approach to increasing daily physical activity: The First Step Program. The main objective of this work was to develop an effective program, but one that was also acceptable to individuals with Type 2 diabetes and also feasible for diabetes educators to deliver. We begin with a detailed presentation of the theory driving the program design and the framework for subsequent evaluation. We then present the formative evaluation of the pilot delivery of the First Step Program (including a detailed program description) and a summative evaluation presenting the pilot program's impact. Final recommendations are intended to direct further research and practical application.

From the early stages, the First Step Program was organized, planned, and implemented in such a manner that its operation and effects could be subjected to rigorous program evaluation (American Public Health Association, 1987). *Program evaluation* is a systematic data collection process for the purposes of decision-making with regards to the implementation, operation, modification, continuation, or expansion of a program (Myers, 1999). Approaches to program evaluation include formative evaluation (also known as market testing, field testing or pilot testing), implementation evaluation (an appraisal of the extent to which a program conforms to the original plan), process evaluation (appraisal of program delivery under normal operation), and summative, or outcome evaluation (the appraisal of the program's impact) (Myers, 1999; Patton, 1997; Rossi, Freeman, & Lipsey, 1999). A mixed method approach to program evaluation was used (Israel et al., 1995). This approach expands the depth and range of information collected and increases validity of conclusions (Steckler, McLeroy, Goodman, Bird, & McCormick, 1992).

5.1 Development of a Theory-Based Physical Activity Program

5.1.1 Introduction

Despite the well known benefits of increased activity for individuals with Type 2 diabetes, only a handful of studies have attempted to optimize adherence and/or alter habitual activity (Hartwell et al., 1986; Lehmann et al., 1995; Ligtenberg et al., 1997; Raz et al., 1994; Samaras et al., 1997; Vanninen et al., 1992; Walker et al., 1999; Wing et al., 1988; Yamanouchi et al., 1995). The majority of these studies have focused on class-based programs; the long-term adherence to such structured programs is low (Ecclestone et al., 1998; Schneider et al., 1992).

In order to make physical activity more accessible, the ADA (1999) has endorsed the U.S. Surgeon General's recommendations (1996) to accumulate 30 minutes or more of moderate activity on most, if not all, days of the week. To date, only two studies have examined daily physical activity interventions with individuals with Type 2 diabetes (Walker et al., 1999; Yamanouchi et al., 1995). As described in detail in Chapter 2, Yamanouchi et al. (1995) used a pedometer to monitor 6-8 weeks of increased daily physical activity in a hospital-based population. Walker et al. (1999), meanwhile, instructed participants to walk 60 minutes five days each week for 12 weeks. Both studies reported excellent adherence to these physical activity recommendations and reported results are promising.

Although these studies can serve as inspiration, neither serve as useful clinical program templates because they lack a detailed program or intervention theory and because they may not be feasible for non-researchers to deliver in a real-world context. Program theory is necessary to organize and explain what happens in the program and why (Sidani & Braden, 1998; Weiss, 1997). A program theory can be formulated from published literature and should also involve consultation with stakeholders including program deliverers and recipients (Patton, 1997). We have already published the results of a program needs assessment conducted with diabetes educators and individuals with Type 2 diabetes (Tudor-Locke et al., 1998) and we have continued to consult with these two groups throughout this projects (see section 5.3 for more details).

Sidani and Braden (1998) explain that careful consideration of program theory is critical to delivery in clinical settings (e.g. nursing interventions). They identify the following essential elements of an intervention theory: a problem definition, the critical inputs, the mediating processes, the expected outcomes, the extraneous factors, and implementation issues (Sidani & Braden, 1998). All elements of an intervention theory must be identified and described as part of the program evaluation. Following the structure outlined by Sidani and Braden (1998), the purpose of this section is to fully describe the underlying program theory for the First Step Program.

5.1.2 Problem Definition

A definition of the problem should thoroughly describe the condition, the target population, and the circumstances (Lipsey, 1993). Diabetes is a prevalent problem, and despite the known multiple benefits of regular activity for individuals with Type 2 diabetes, this population is typically sedentary (Ford & Herman, 1995; Hays & Clark, 1999).

Current guidelines for diabetes educators to counsel clients are poorly defined and delivered (Tudor-Locke et al., 1998). In 1997, the ADA and the ACSM published joint consensus statements regarding diabetes and exercise in their respective journals. According to these recognized authorities, activity sessions at an intensity of 50-80% of maximal aerobic capacity, 3-4 times a week, for 30-60 minutes, elicit the greatest improvements in glycemic control and insulin sensitivity. Within the same documents, however, concluding statements endorse the Surgeon General's recommendations (1996), described earlier. Such mixed messages continue to frustrate programming efforts. And although we know a great deal about delivering structured exercise programs, a detailed program model encompassing the latter recommendation does not currently exist.

5.1.3 Critical Inputs

The specification of critical inputs identifies practical aspects of the intervention theory, or what should be done (Lipsey, 1993). Drawing upon previous literature, we know that the most acceptable physical activity interventions in the general population have been home-based, moderate in intensity, involved walking, and included regular follow-up contact (Hillsdon & Thorogood, 1996; Hillsdon et al., 1995). Individuals with Type 2 diabetes value simple and specific direction that can be individualized according to ability, lifestyle, and preferences (Tudor-Locke et al., 1998).

A pedometer, used as both an environmental cue and as a feedback tool, is a novel but promising approach to increasing daily activity in sedentary populations (Dunn et al., 1998). Goal-setting is commonly used in clinical interventions by health care workers. Yamanouchi et al. (1995) reported that hospital-based subjects with Type 2 diabetes instructed to take 10,000steps/day averaged 19,200±2,100 steps/day during a 6-8 week study. The dramatic difference between prescription and practice suggests that use of pedometers, in combination with goal-setting may be an effective way of increasing lifestyle activity.

Although it is tempting to dictate Yamanouchi's goal of 10,000steps/day, no evidence exists to support an arbitrary threshold prescription. Self-selected, realistic goal-setting based on baseline values and/or prior accomplishments and feedback (Marcus et al., 1996) is likely a more productive approach to increasing activity via a pedometer. Cross-sectional data suggest that 10,000 steps/day is a lofty goal for typically sedentary free-living populations (Bassey, Bendall, & Pearson, 1988; Bassey et al., 1987; Gardner et al., 1997; Schmalzried et al., 1998; Walsh et al., 1997). Typical values range from 3,500-7,000 in older individuals and those living with chronic conditions (refer to Chapter 1 and Table 1).

Self-contracts are a means of clearly articulating physical activity goals and strategies (Marcus et al., 1996) and are frequently used in clinical applications. Self-monitoring, informally by referring to a pedometer through out the day, and more formally, by recording daily pedometer values on an activity calendar, can help reinforce activity behaviours (Marcus et al., 1996).

Readability of all participant resource materials is another important factor in diabetes education (Leichter, Neiman, Moore, Collins, & Rhodes, 1981; Siminerio & Frith, 1993). A mismatch between level of written materials and reading comprehension levels of the target audience frequently occurs (Hosey, Freeman, & Stracqualursi, 1986; Leichter et al., 1981; McNeal, Salisbury, Baumgardner, & Wheeler, 1984; Wysocki, 1989). Thus, program developers must be cognizant of the needs of the deliverers (time, feasibility) as well as the needs of the intended target audience. Materials must be understandable and acceptable to clients themselves.

5.1.4 Mediating Processes

The mediating processes are the connections or linkages between the immediate expected changes and the desired outcome (Lipsey, 1993). A number of behavioural theories and models have guided physical activity promotion efforts (King et al., 1992; Marcus et al., 1996). The most promising approaches include applications of social cognitive theory (Bandura, 1986; Bandura, 1997), a theoretical framework that identifies the constructs of self-efficacy and social support as potentially important mediating variables in interventions aimed at altering physical activity behaviours (Sallis & Hovell, 1990). Social support will be dealt with as an extraneous factor modifying behaviour change. Sources of self-efficacy include performance accomplishment, vicarious experience, verbal persuasion, and physiological state (Bandura, 1986).

Performance accomplishment refers to an individual's performance of a task/behaviour and their experiences of mastery. It is the most influential source of self-efficacy. Exercise self-efficacy has been shown to increase following a single bout of exercise (Ewart, Taylor, Reese, & DeBusk, 1983). While exercise is a frequent topic of discussion in diabetes education programs, opportunities to actually experience physical activity as part of the education session are rare (Tudor-Locke et al., 1998). In order to increase self-efficacy for walking with a pedometer, it is necessary to build such a component into the program.

An incremental approach to increasing weekly physical activity volume allows for progression without compromising self-efficacy (Wing, 1989). Encouraging clear and specific self-selected goals can facilitate a sense of mastery (Gonzalez, Goeppinger, & Lorig, 1990). Feedback (from a variety of sources, including a pedometer) based on performance may also boost self-efficacy levels (McAuley, Bane, & Mihalko, 1995; McAuley, Courneya, Rudolph, & Lox, 1994).

Vicarious experience is somewhat less influential and refers to boosting self-efficacy through observing similar others' successful performance. For example, observing and participating along side other people with diabetes, and/or watching video taped recordings of appropriate models engaged in successful performance of physical activity. A group-based program would provide opportunity for vicarious experience as well as social support for similar others.

Verbal persuasion is simply telling the individual that they can do it. The effect of verbal persuasion on self-efficacy is weaker by comparison to the previous two sources of information on cognitive processing, although it remains a common approach in health education. Positive verbal feedback (from both program delivers and participants) can be easily built into a program by providing direction and encouraging feedback.

Physiological state describes an individual's state of emotional arousal. Adverse reactions such as fear, depression, and/or nervousness can be interpreted by the individual as an inability to perform a task/behaviour. Self-perceptions and self-monitoring skills predict exercise behaviour (Ewart et al., 1986). For example, sedentary participants not used to exercise may misinterpret increased heart rate as a sign of impairment or dysfunction. It may be possible to help individuals interpret somatic responses to exercise correctly, thereby improving self-efficacy for exercise (Gonzalez et al., 1990). For example, during programmed walks, participants should receive reinforcement to walk at a comfortable and sustainable self-selected pace.

There is evidence that suggests that outcome expectations (e.g., beliefs in the benefits of exercise), when combined with self-efficacy, strengthen the ability to predict exercise adherence in general populations (Clark et al., 1995; McAuley et al., 1995). Outcome expectations are considered particularly important to initiating exercise behaviour in this population (Clark, 1996). Information on the benefits of activity (specific to Type 2 diabetes) may help foster improved outcome expectations. Once active, feedback on achievement of these outcomes (e.g., reductions in waist girth) may facilitate to continued activity.

The transtheoretical model (Prochaska & DiClemente, 1984), discussed in Chapter 3 in detail, argues that specific cognitive and behavioural processes are important at each transitional stage for fostering adoption and adherence to behavioural changes. Since the majority of individuals with Type 2 diabetes already believe they should get more exercise (Searle & Ready, 1991), an appropriate intervention should quickly move beyond raising awareness of the benefits of increased activity and focus on the behavioural processes necessary for action. The emphasis should be on an iterative process of planning strategies, goal-setting, practicing behaviours, reporting progress, and relapse prevention.

5.1.5 Expected Outcomes

The expected outcomes are the desired intervention effects. An intervention theory attempts to explain the nature of outcomes, the anticipated patterns and timing of change, and linkages between primary and secondary outcomes (Lipsey, 1993). The primary intended outcome for this intervention is increased physical activity, defined for this program as steps/day as measured by individual pedometers. The anticipated pattern of change is an increased physical activity level that deteriorates over time and with reduced professional contact (Hillsdon & Thorogood, 1996). The secondary outcomes of interest include cardiorespiratory fitness (determined by feasible and acceptable sub-maximal tests of endurance), cardiovascular risk factors (determined by measures of resting blood pressure, body composition, and blood lipid profile), and perceived well-being (determined by a standardized published tool), all well-known effects of increased physical activity. For this population, the effects of increased activity on glycemic control (determined by fasting and average daily blood glucose levels and/or glycated hemoglobin) are of additional importance.

5.1.6 Extraneous Factors

Extraneous factors include the potential impact of environmental and situational factors, as well as the effects of participant and intervener characteristics (Lipsey, 1993). Extraneous factors, can affect outcomes directly or indirectly (by moderating intervention effects) (Sidani & Braden, 1998). For example, whether or not participants attend group sessions or instead receive face-to-face counseling may have important effects. Individuals with lower baseline levels of habitual physical activity may react differently to an intervention compared already more active individuals. Participant characteristics include: gender; age; time since diagnosis; body mass index; and baseline values of primary and secondary outcomes.

The nature of health education delivery often requires that an intervener (the health educator) interact in a dynamic manner with participants. In such cases intervener characteristics become part of the intervention (Sidani & Braden, 1998). Ideally, the intervention and accompanying materials need to be simple enough to reduce the need for exceptional intervener characteristics or traits.

Although the use of various environmental prompts, cues, and incentives have received some attention in the exercise literature (King, 1997; King et al., 1992), the most likely extraneous factor affecting physical activity behaviour is social support (Hillsdon & Thorogood, 1996; King et al., 1992). Sources of social support may come from peers, professionals, family or personal networks and may have either a positive or negative effect on physical activity behaviour (Chogahara et al., 1998). Only one physical activity intervention in Type 2 diabetes, however, has made an attempt to manipulate personal network social support in an attempt to improve adherence (Lehmann et al., 1995). Unfortunately, it lacked a description of effectiveness. Nevertheless, it is generally recognized in the literature that social support can have a very powerful influence on physical activity adoption and maintenance, and therefore any contemplated intervention should attempt to optimize all sources.

5.1.7 Implementation Issues

Implementation issues include the resources and systems necessary for program delivery (Lipsey, 1993). These include resources related to setting, equipment, and intervener skills and training (Sidani & Braden, 1998). A practical program must be simple enough to be delivered in a variety of settings, with low equipment demands, and minimal intervener training requirements. Such programs are less likely to experience problems with implementation.

Participant recruitment and follow-up contact represent program delivery systems. Recruitment is a critical first step in the evaluation of physical activity interventions. It is important to identify individuals most likely to benefit from a physical activity intervention, that is, truly sedentary or underactive individuals. Our experiences with recruitment and subject screening were presented in Chapter 4.

Recent review of physical activity promotion studies indicate that professional contact, in the form of telephone or face-to-face contact appears to be an important strategy preventing dropout or relapse (Hillsdon & Thorogood, 1996; Hillsdon et al., 1995). Therefore, it is necessary to consider program strategies for follow-up contact that is feasible and acceptable to both participants and deliverers.

5.1.8 Summary

The First Step Program is a theory-based daily physical activity intervention designed to increase the daily physical activity levels of sedentary individuals with Type 2 diabetes. Formulation of a reasonable and defensible program theory is a critical step in the development and implementation of a successful intervention and serves to focus subsequent program evaluation and interpretation of evaluation results (Sidani & Braden, 1998; Weiss, 1997). The development and evaluation of the First Step Program carefully considered all the recommended elements of intervention theory: a problem definition, the critical inputs, the mediating processes, the expected outcomes, the extraneous factors, and implementation issues (Sidani & Braden, 1998). Further, program development was guided by the applicable literature and by a needs assessment conducted with both program deliverers (diabetes educators) and recipients (individuals with Type 2 diabetes) (Tudor-Locke et al., 1998). The next section presents the formative evaluation of the First Step Program, including a detailed program description.

5.2 Formative Evaluation of The First Step Program

5.2.1 Introduction

Formative evaluation is the systematic study of program models in their early stages of development and delivery, prior to larger-scale implementation, production or dissemination (Myers, 1999; Rossi et al., 1999; U.S. Department of Health and Human Services, 1992). The objectives of formative evaluation are three-fold: 1) to assess the feasibility of program delivery (including implementation and delivery); 2) to assess the acceptability of program activities and materials to both deliverers and clients; and, 3) to identify barriers to optimal delivery. Information derived from formative evaluation is used to make decisions concerning implementation, and to modify and guide delivery to optimize benefits in the target population (Myers, 1999; Rossi et al., 1999; U.S. Department of Health and Human Services, 1992).

This section presents the program description and describes the formative evaluation of the First Step Program, a new theory-based approach for increasing daily physical activity in individuals with Type 2 diabetes.

5.2.2 Program Description

The First Step Program is an 8-week program designed to incrementally increase habitual activity levels in sedentary individuals with Type 2 diabetes. The program is divided into two distinct phases directed at adoption and adherence, respectively. The adoption phase consists of four weekly education and counseling meetings (in a group or face-to-face setting), combined with individual goal-setting and self-monitoring using a pedometer for feedback. The adherence phase occurs over a subsequent 4-week period with continued individual goal-setting and self-monitoring and limited telephone contact.

As recommended by Thygerson (1977) in the development of educational programs, we developed a task analysis, presented in Table 8. The task analysis is displayed in Table 8, was subsequently used to construct learning objectives (Ballard, 1990), presented in Table 9-11. Basically, the task analysis lays out what the learner needs to know, and the learning objectives describe how it will be delivered and evaluated.

Evening meetings (1.5-2 hours in length) were held at the diabetes education centre, a facility familiar to all participants. Facility resources included an education room (containing a conference table and audio-visual equipment) and a gymnasium. Participants received a workbook (developed specifically for this program) containing key definitions (physical activity, exercise, physical fitness, and health), recommendations for daily physical activity (30 minutes or more of moderate activity, like brisk walking, on most, if not all days of the week), question and answer tasks to guide cognitive processes, weekly goal-setting worksheets, and calendars to record their accumulated steps/day. Participants were encouraged to attend all meetings; face-to-face sessions were scheduled when this was not possible.

The format of the meetings was repetitive and consisted of: progress reports, a brief group walk (10 minutes the first night, 20 minutes the second, and 30 minutes on the last two nights), a discussion session to plan strategies, and personalized goal-setting for the next week. Participants were encouraged to talk with each other and the interveners during group walks. Topics of conversation were not planned and varied to include such topics as holidays, hobbies, work, family, and current events.

To encourage the use of existing support networks, participants were asked whom they intended to show their pedometer to, and how these individuals might help them succeed in meeting their goals. Participants were also encouraged to bring a support person to the weekly meetings as a guest. Reflecting on their previous week's average pedometer values, the number of steps taken during the timed walk, and the strategies they intended to employ, participants were encouraged to set a new personal daily activity goal (measured in steps/day) each week.

Between sessions, participants were encouraged to wear their pedometers during waking hours and to monitor their activity using a combination of pedometer feedback and daily goals. Personal progress was recorded on calendars as accumulated steps each day. At the end of the week, they tallied the number of days when goals were attained, the total steps taken during the week, and the daily average. These values were entered on their calendars in a weekly summary section.

At the last scheduled session, participants were given a certificate of completion and encouraged to either increase or maintain their new activity levels using the pedometers and calendars for a further month. Two motivational telephone calls (scheduled during the first and third weeks following the final session) were completed by one of the interveners (C.T.-L). Participants were simply asked: "How is your First Step Program going?" Calls were made (with permission) in the evenings, after 6:30pm, to participants' homes. If an answering machine was reached, a message was left to indicate another call would be made.

The two interveners (C.T.-L. and T.G.; females in their mid-30's) were doctoral students, one in health studies, and the other in education. The former is the author of this thesis and the developer of the First Step Program. Both had previous training in kinesiology and adult education and were experienced educators and program deliverers. Humor was readily incorporated into program content, first names were used, clothing was informal and appropriate for activity, and all participants were encouraged to contribute to discussions.

5.2.3 Methods

Ethical approval was obtained from the University of Western Ontario Review Board for Health Sciences Research Involving Human Subjects. As noted in Chapter 4, eighty-six individuals were identified by manual patient chart review at the participating diabetes education centre. Potential subjects were 40-60 years of age, BMI 28-35, had attended standard diabetes education, and were three months to 1-year post-diagnosis. Physician consent was obtained prior to contact. Only 1 physician declined consent (patient was being recruited for another, unrelated study). Telephone screening was used to verify chart information and to establish that persons were either sedentary or under-active (i.e., they did not meet either traditional fitness-based exercise prescription (ACSM, 1998) nor the more recent activity-based public health messages (Pate et al., 1995).

Two (2%) individuals were excluded due to involvement in formal exercise programs; 44 (51%) were excluded due to self-reported activity levels higher than the public health messages. Two (2%) were excluded due to incorrect diagnosis dates. Thirteen (15%) were lost to contact. Further exclusions were: 1) treated with insulin (*n*=1); 2) unable to independently climb a set of stairs (*n*=1); and, 3) documented coronary heart disease, microvascular disease, or autonomic neuropathy (*n*=2). People with moderate hypertension or controlled hypertension (with medication) were eligible for the study.

In total, 20 (23%) eligible individuals were identified. Eight of these individuals (9% of the original sample) declined to participate citing that they were "too busy" (*n*= 5) or "not interested" (*n*= 3). Twelve unacquainted individuals agreed to participate (recruitment efficiency=14%).

Two individuals (1 male, 1 female) dropped out before the intervention began ("too busy"), while another female dropped out after attending one session and a face-to-face meeting (citing changes to employment). Nine individuals (3 males, 6 females; mean age 53±6 years, 95%CI=48-59) completed the First Step Program.

Subject characteristics were obtained from education centre patient charts and a background questionnaire (see Appendix A), which included questions about outcome expectations with regards to physical activity (see Appendix B). The Modified Activity Questionnaire, MAQ (Kriska et al., 1990), was administered to describe occupational and leisure-time activities recalled over the previous year. The MAQ was described in detail in

Chapter 3. Other questionnaires and outcome measures will be described in the subsequent section detailing the summative evaluation.

Group sessions were video- and audio-taped with subjects' permission. The two program interveners took weekly fieldnotes (C.T-L. was present at all sessions, T.G. was unable to attend one session) concerning observations of the program and participants' informal comments. More formal focus groups (Krueger, 1994) were held to explore issues related to adoption and maintenance. Focus groups were held immediately following the first 4 weeks of group meetings (with 6 and 3 participants respectively). Two months post-intervention, after all program contact was completed and pedometers had been returned to the study centre, focus groups were held again (with 6 and 2 participants, respectively). A separate focus group was held with 7 diabetes educators (who had also worn pedometers and participated in their own First Step Program) to assess feasibility of delivery and dissemination. Focus group data were transcribed from videotape, verified by audiotape, and analyzed for content, pattern, and theme (Krueger, 1994; Luborsky, 1994) using QSR NUD*IST qualitative analysis software (Richards & Richards, 1991).

The First Step Program Participant's Workbook was assessed for readability using a commonly accepted procedure to assess reading grade levels: SMOG formula (McLaughlin, 1969). The SMOG uses a total count of polysyllabic (three or more syllables) words in a sample of three sets of 10 sentences taken from the beginning, middle, and end of the document being assessed. The total count of polysyllabic words includes repetitions of the same words.

5.2.4 Results

The nine subjects completing the First Step Program were 8.7±3.7, 5.8-11.5 months post-diagnosis with Type 2 diabetes at baseline (T1). Seven (78%) were being treated with diet only while two (22%) were taking metformin oral hypoglycemic medication. Three (33%) had some high school, two (22%) had a high school diploma, three (33%) had some post-secondary schooling, and one (11%) was a university graduate. One (11%) was a current smoker, one (11%) was an occasional smoker, and the remaining 7 (78%) were former smokers, having quit and average of 11.7±9.6, CI=2.8-20.6 years previously. The most common diagnosed chronic conditions reported other than diabetes were high blood pressure (7, or 78% of the sample), chronic asthma, emphysema, or bronchitis (3, or 33%), allergies (3, or 33%), high cholesterol (2, or 22%), and back problems (2, or 22%).

Three (33%) perceived their health as fair, 5 (56%) perceived it as good, and one perceived their health as excellent. All perceived themselves to be overweight. According to self-reported stage of change at T1, 1 subject was in contemplation, 7 were in preparation, and 1 was in action. Although during telephone screening they all indicated that they were inactive, when queried about exercise frequency, five subjects reported that they rarely or never participated, two reported that they participated normally once or twice on a weekly basis, and two reported that they participated at least three times. Three perceived their physical fitness to be poor, four perceived it to be average, and two perceived it to be very good.

Five were office workers, two were non-office workers (parking attendant and domestic help), one was retired, and one worked part-time. An average of 4.5±3.8, CI=1.6-7.3 work hours was spent sitting. Gardening was the most frequently reported activity on the MAQ (5, or 56%). Walking was the second: 4, or 44%. The following activities were reported by no more than one subject: swimming, cycling, softball, volleyball, skating, dancing, tennis, golf, and paddling. No other activities were reported. Over the last year, subjects engaged in 0.83±0.3, CI=0.4-1.2 hours/week of leisure time activity. There was no significant change when walking for exercise was removed: 0.55±0.2, CI=0.20-0.90 hours/week. No credit was given for any subject's occupational activity.

Participants were enthusiastic about the First Step Program, specifically the facilitated group-based approach, the brief walks, and the personalized goal-setting. Between sessions, all subjects wore their pedometers every day for two months, verified from completed calendars. One subject reported dropping her pedometer down the toilet, rescuing it, and putting it back on immediately. Another subject lost his pedometer at work, went out and purchased another, and retraced an earlier walk he had taken in the day so that he could accurately report his steps taken.

All found the pedometer a useful motivator and source of feedback. Common or illustrative quotes were:

"I have never realized how inactive I was before I started looking at (the pedometer values) and thinking, holy, I did not do very much...now I make a real effort to get out there and walk."

"Every time you think about it, you open up (the pedometer) and look at your numbers. You say, Oh my numbers are low. You got to get out there and do it. Without that pedometer I know that I would not have pushed myself as much."

All participants recorded daily step values over a 2-month recording period - there were no missing data. The calendars proved to be both an acceptable monitoring tool and an effective feedback tool as illustrated by the following comment:

"You had your bad days and your good days and you could look and see if you were behind. It is right there in front of you all the time. Every morning you look at it...it was gratifying."

Although telephone follow-up contact appeared to be simple and feasible, in reality, several attempts were often necessary outside typical workday hours, a practice that was not acceptable to the diabetes educators we consulted. Only one participant provided a day time contact number; the others preferred to be contacted solely at their residence and in the evenings. When this issue was later raised in the focus group discussions, some individuals referred to busy schedules and not wishing to be disturbed by telemarketing approaches. Two subjects indicated, in good humour, that when they saw the call display indicating the caller's identify, they would not pick up the phone. During the same time frame, a student researcher was attempting 24-hour dietary recalls with the same subjects by telephone and was experiencing similar problems with contact.

Five participants brought support people to at least one of the group meetings. Most participants could relate specific instances of social support from their individual networks. For example:

"The more people you told, the more people you had helping you....sort of pushing you...not literally but invisibly behind you...sort of cheering you on...I think that's more of a big deal because you told them."

In one case, however, the main support person acted to hinder continued physical activity:

"I told (my husband) a bit about it but he teased me. He can't walk...has a bum knee. He's too interested in television," and later: "I've fallen off the wagon. If I want to spend time with him I have to watch television...I don't walk as much."

The First Step Program Participant's Workbook was assessed at a readability level of grade 8 using the SMOG index (McLaughlin, 1969). There was a total of 41 polysyllabic words counted in the sample sentences chosen. The most frequently used three syllable words were confident (20 times), physical (11 times), average (7 times), strategies (6 times), exercise (3 times), and benefits (3 times). The most frequent 4 syllable words were activity (21 times), pedometer (17 times), diabetes (4 times), everyday (4 times), and moderately (4 times).

Diabetes educators were very positive about the First Step Program and accompanying materials, viewing both as simple and appropriate for sedentary populations. Their concern, however, was scheduling the 4 group meetings (and individual make-up sessions) and follow-up calls into already demanding work commitments.

5.2.5 Discussion

Although the literature suggests that inactivity is prevalent in individuals with Type 2 diabetes (Ford & Herman, 1995; Hays & Clark, 1999), we found that a high proportion of the people we tried to recruit claimed they attained minimal public health recommendations. This finding illustrates the potential misclassification of this population due to recall bias using self-report (Ainsworth et al., 1998; Masse et al., 1998). This issue was discussed in detail in Chapter 2.

Using pedometers to gauge and modify personal physical activity levels was both feasible and acceptable. Hatano (1993) has reported similar acceptance determined from testimonials of use: it gave meaning to walking, it increased intentional walking behaviours, it increased the importance of daily physical activity relative to sport and exercise, and it re-sensitized users to distances traveled.

Consistent with other literature (Chogahara et al., 1998), social support, in the form of the initial group meetings (peers and interveners), but especially from existing support networks, appeared to be an important factor. Individual social support networks can act to facilitate or inhibit adoption and maintenance of physical activity (Chogahara et al., 1998). For the most part, participants in the First Step Program were able to access facilitative social support from their own networks.

Professional follow-up contact has been shown to increase adherence to lifestyle behaviour change; telephone contact specifically is considered a feasible method (DeBusk, 1996). Our own experience from this pilot project was not encouraging. The fact that the majority persons preferred to be called outside typical workday hours (and callbacks were often necessary) reduces the acceptability of this contact method for clinicians and educators. Telephone contact may be less necessary for this program given that participants receive frequent pedometer feedback and reinforcement and that they have been trained to access support from their personal networks. Nevertheless, we intend to evaluate alternative methods of follow-up such as postcards.

Readability, assessed by the SMOG scale (McLaughlin, 1969) can be improved by substituting words with more syllables with words with fewer. The following words have now been changed: 1) confident to sure; 2) strategies to plans; 3) everyday to every day; and, 4) moderately to some what. The newly calculated SMOG level is now grade 7, still two grades higher than suggested comprehension levels of the target audience (McNeal et al., 1984). There are now a total of 20 polysyllabic words in a comparable sample of sentences. Sixteen of the 20 words are due to repeats of the same words: physical, activity, exercise, and pedometer. Due to the nature of the topic, however, it is difficult to avoid such terms. For clarity purposes, the terms physical activity, physical fitness, and exercise are defined in simple terms in the workbook.

Despite the optimism associated with the First Step Program, further evaluation is necessary to determine the most feasible methods of dissemination within the existing diabetes education infrastructure. Large scale dissemination is likely contingent on changes to education standards which include physical activity. Currently, diabetes educator competency regarding physical activity education is considerably lower than for nutrition, medication, and other aspects of diabetes management (Tudor-Locke et al., 1998).

In summary, the formative evaluation of a novel daily physical activity intervention for individuals with Type 2 diabetes was guided by program theory. The First Step Program is a promising novel initiative that is acceptable to both diabetes educators and their clientele. Recommended modifications include an objective recruitment procedure and further evaluation of methods of follow-up contact. Successful dissemination likely requires policy changes reflecting an acceptance of the importance of physical activity in the management of Type 2 diabetes.

5.3 Summative Evaluation of The First Step Program

5.3.1 Introduction

The First Step Program was described in detail in the previous section. Briefly, it is a theory-based physical activity intervention that uses pedometers to encourage self-monitoring and behaviour change. There are two distinct phases to the First Step Program reflecting the processes of adoption and adherence to a behaviour change: 1) 4 weekly group meetings with similar others (at which strategies and progress are openly discussed) combined with self-monitored activity using a pedometer between sessions; and 2) a further 4 weeks of continued individual practice with minimal professional contact in the form of two telephone calls.

The purpose of this section is to describe the summative evaluation, that is, the impact of participation in the First Step Program on sedentary individuals with Type 2 diabetes with regards to the hypothesized mediating process variables (self-efficacy, outcome expectations, stage of change) and the primary and secondary outcomes of interest (physical activity, physical fitness, cardiovascular risk factors, glycemic control and perceived well-being). The patterns and timing of these changes in self-efficacy and physical activity (steps/day) was examined over the phases of adoption and adherence.

Experience with measurement of these variables is shared and recommendations are made in regards to improving evaluation of the First Step Program and other similar physical activity interventions.

5.3.2 Methods

The summative evaluation is based on the results of the 9 subjects (characteristics and recruiting issues were presented in the previous section) completing the First Step Program. Subjects were assessed at baseline (T1; prior to beginning the program), after 1 month of weekly First Step Program meetings (T2), after another month of individual self-monitored activity with limited telephone contact (T3), and at a 2-month follow-up with no contact, following return of the pedometer (T4). Christmas holidays occurred between T2 and T3 for all subjects. In addition, pattern of change of some outcome and mediating process variables were collected over the course of the adoption and/or adherence phases of the program, as opportunity permitted, and as described below in detail.

5.3.2.1 Adherence

Attendance at the 4 scheduled group sessions was recorded. When a session was missed, an individual counseling session was scheduled. During the first two months of the intervention, subjects were instructed to report daily pedometer values on activity calendars. The average number of steps/day and the number of days when individual goals were reached were tabulated directly from the activity calendars and were studied to identify adherence patterns. To assess the effect of Christmas holidays on daily activity, the average values of the 7 days leading up to, and following Christmas Eve, Christmas Day, and Boxing Day were compared with the average values of these three days.

5.3.2.2 Mediating processes

Subjects completed background questionnaires (Appendix A) at each time point regarding demographic information and the importance of exercise (5 point scale: 1=not at all important to 5=extremely important). Additional questions were imbedded in the background questionnaire to determine percent confidence in outcome expectations for lowered blood glucose levels, weight loss/maintenance, and prevention of diabetes complications, with regards to increased physical activity (Appendix B). Stage of exercise behaviour change (Canadian Society for Exercise Physiology, 1998) was also collected. At T2-T4, questions were added to the background questionnaire to solicit changes in television viewing habits (taken from the MAQ; (Kriska et al., 1990) and confidence with ability to adhere to increased physical activity levels (Appendix C). Subjects were asked about changes to physical activity and medications in the interim.

The Diabetes Self-Efficacy Scale, DSES (Crabtree, 1986) was used to quantify changes in self-efficacy at the primary assessment points. The DSES is a 25-item Likert scale (1=strongly disagree to 6=strongly agree, and non-applicable) containing 8 diet, 6 exercise, 7 medication-taking, and 4 general diabetes self-efficacy statements. The internal consistency of the DSES is .71, based on Cronbach's alpha coefficient. Alphas for the subscales are .77, .65, .60, and .56, respectively. Negatively worded items were reverse scored as recommended by the instrument's developer (M.K. Crabtree, personal communication). Non-applicable items were treated as missing data.

To explore patterns in self-efficacy change with regards to the First Step Program, a percentile rating of self-efficacy ("stick-to-it-ness"), and the number of days/week the subject felt confident that they could achieve their goal was recorded during each of the initial 4 weeks of group meetings (immediately following individual goal-setting) and again at T2-T4.

The pattern of goal-setting behaviour (amount of self-selected increments) during the initial 4 weeks was examined. Goal attainment was expressed as the number of days per week participants' goals were attained, recorded from their activity calendar.

5.3.2.3 Outcomes

Volume of current daily physical activity was determined in two ways: 1) by average steps/day recorded via pedometer; and, 2) average daily energy expenditure calculated from a log of activities recorded over a 3-day period, including one weekend day (a detailed description of the instrument and its psychometric properties are presented in Chapter 3) (Bouchard et al., 1983). Subjects were encouraged to engage in their typical activities over the 3-day period. Subjects were also instructed to seal the pedometer with a sticker to deter them from modifying their activities. Sealed pedometers and activity logs were retrieved directly from subject's homes, primarily from outside mailboxes. Pedometer data was recorded immediately and the average steps/day was used for data analysis. In order to translate steps taken into time of activity, the number of steps taken in 20 minutes of continuous walking was recorded the second night of the First Step Program and used for conversion purposes.

Test-retest reliability of the 3-day pedometer values (separated by one month with no intervention) was conducted on 5 subjects (2 male, 3 female; age 54.2±3.5, CI=50.0-58.5 years;

BMI 31.9±2.8, CI=25.4-35.5; 11.2±3.6, 6.8-15.6 months since diagnosis). The steps/day obtained during the two reliability testing periods were similar: 6,078±3,654, CI=1,541-10,616 vs. 5,828±2,962, CI=2,151-9,506 (paired *t* test; p=.79). The intraclass correlation coefficient (Snedecor & Cochran, 1980) was 0.91.

Inactivity was determined in two ways: 1) from a general question regarding duration of weekly television viewing habits; and, 2) from the average daily total hours in category 2 (sitting activities) recorded on the 3-day activity log.

A physical assessment included resting heart rate and blood pressure, weight, waist and hip girths. Height was only assessed at T1. Assessment protocols described in the Canadian Physical Activity, Fitness and Lifestyle Appraisal were followed (Canadian Society for Exercise Physiology, 1998).

A self-paced stepping test was administered, modified from work with self-paced walking tests (Himann, D.A, Rechnitzer, & Paterson, 1988). Subjects performed 20 up-down cycles at each of three frequencies of stepping on a 2-tier step (20.3 cm step height). Subjects were asked to perform at what they considered to be a slow pace, then a normal pace, and finally a fast pace. A similar protocol predicts maximal aerobic capacity in older individuals, regardless of whether it is administered by trained or untrained personnel (Petrella, Koval, Cunningham, & Paterson, 1998) and it has been shown to be sensitive to a physician counseling intervention designed to increase physical activity (Petrella & Wight, 1999). Time to complete (seconds), heart rate (beats per minute), and subject perceived rating of exertion (Borg, 1982) were recorded. Rated perceived exertion is considered to be a clear, concise and effective means of representing the relationship between sense of effort and physical work performed (Russel, 1997).

An O_2-pulse variable (ml/beat) was calculated at each time point from O_2 cost of stepping x body weight/heart rate. O_2 cost of stepping was calculated from the ACSM formula for stepping (ACSM, 1995). The purpose of this conversion was to allow for a uniform comparison of the multiple variables (Hiltz, 1991). Reliability analysis of the self-paced step test is presented in Table 12. The same 5 subjects who provided test-retest pedometer data also completed all protocols at both time points; only three subjects completed the fast protocol. There were no differences in any variable between testing periods (paired *t* test) and intraclass correlation coefficients were high (ICC=0.78-0.97), with the exception of fast-paced time to complete (ICC=0.41).

Photocopies of personal blood glucose records were obtained from as many subjects as possible at each time point. A weekly average blood glucose level was calculated from all individual data reported for the two weeks prior to intervention, the 4 weeks of weekly group meetings, the 4 weeks of individual self-monitored activity, and the 8 weeks until the final follow-up assessment.

Psycho-physical well-being was assessed using the Vitality Plus Scale, VPS (Myers et al., in press). The 10-item VPS, developed for use in older populations, shows good internal consistency and reproducibility and assesses items shown to be enhanced with physical activity (e.g., sleep, energy level) (Myers et al., in press). A total score was calculated out of 50.

At baseline and at two random time points after entry into the study (between T2 and T3; and between T3 and T4), two nutrition students conducted a telephone-administered 24-hour dietary recall. This approach to dietary interviews in considered to be both a feasible and acceptable method of estimating group nutrient intake means (Fox, Heimendinger, & Block, 1992). All of the subjects recruited had recently attended standard diabetes education, including training in recognition of portion sizes. Nutrient intake data (total kilocalories, and grams of fat, protein, and carbohydrate) were assessed by a trained nutritionist (M.T) using FOODSMART nutrition analysis software.

5.3.2.4 Data treatment and statistical analysis

Data are expressed as means ±SD, 95% CIs. An analysis of variance for repeated measures was used to examine within-subject effects; the Greenhouse-Geisser epsilon F value (Winer, 1971) was evaluated for significance. Post-hoc *t* tests were then used to explore significant changes over time. Differences in dietary data were analyzed between time points and relative to original dietary recommendations obtained from education centre patient charts. Case summaries were used to present transition through stages of change at each time point. Quantitative data were analyzed using SPSS Version 8.0 Statistical Software; $p < .05$ was considered to be statistically significant.

5.3.3 Results

5.3.3.1 Adherence

Seven participants attended all four weekly group meetings. One person re-scheduled two face-to-face appointments (due to work conflicts) while another re-scheduled 1 (due to transportation problems). Both of these subjects initiated the re-scheduling process prior to the weekly group meeting.

All nine subjects wore their pedometers and recorded steps/day as verified from calendars. There were no missing pedometer data. Pattern of change is presented as average steps/day at all major time points and through the 8 weeks of program (Figure 1). Christmas holidays occurred during the adherence phase for all subjects. There were no statistically significant differences in steps/day recorded during the seven days prior to (10,875±3,265, CI=8,366-13,386), or following (10,427±3,696, CI=7,587-13,268), the three consecutive holidays including Christmas Day (8,516±3,352, CI=5,940-11,093).

5.3.3.2 Mediating processes

Data analysis of the DSES was problematic due to the large amount of missing data recorded (subjects selecting the non-applicable option). Descriptive data for each of the subscales are presented in Table 13 along with the number of subjects on whom complete data was collected. We were unable to confidently perform any statistical analysis. Caution is recommended when interpreting this data as there was no consistency in which subjects completed the DSES subscales.

The frequency of self-reported stage of change is presented as case summaries for each time point in Table 14. At T1, one was in precontemplation, seven were in preparation, and one was in action. By T4, two were at preparation, five were in action, and two were in maintenance.

The perceived importance of exercise to the subject's regular routine changed over time (as shown Figure 2; F=20.725, p=.000). T2 was significantly higher compared with all other time points (p<.05). There was no difference between T3 and T4 and both were greater than T1 (p<.05).

Physical activity outcome expectations for lowered blood glucose levels, weight loss/maintenance, or prevention of diabetes complications were high (82.2-93.3%) and did not differ at any time point (see Table 15).

Figure 3 shows the average increase in goals in steps/day over the initial 4 weeks of the program. There was a trend for decreasing incremental goals that was not significant (F=2.144,

p=.147). Goal attainment, or the number of days when goals were attained during the week, decreased over the course of the 8-week program (as shown in Figure 4; F=3.820, p=.016).

The apparent decrease in confidence to "stick to it" was not statistically significant (as shown in Figure 5; F=2.298, p=.126). Likewise, the number of days per week that subjects were confident about attaining their goals did not change over time (as shown in Figure 6; F=2.650, p=.075).

5.3.3.3 Outcomes

Indicators of physical activity and inactivity are displayed in Table 16. Daily steps/day ascertained from the 3-day blinded assessment period increased significantly from baseline and remained elevated for the duration of the study period. During the 20-minute timed walk, subjects took 2,198±281, CI=1,982-2,415 steps. Based on this, the T4 increase in physical activity from baseline translates to 22.6 extra minutes of walking every day.

Energy expenditure (determined from the activity log) did not reflect pedometer changes; the only significant change observed was at T3. There was no change in the number of hours sitting obtained from the activity log at any time point. There was no change in time spent television viewing.

At T1, subjects' BMI averaged 32.9±3.4, 30.2-35.5. All other anthropometric measures are displayed in Table 17. There was no change in weight over the duration of the study. Waist girth was significantly reduced at T2, and at T3 was significantly reduced from T2. At the 2-month follow-up, waist girth remained significantly reduced from T1. Hip girth showed a reducing trend that was not significant. Waist to hip ratio remained unchanged.

Indicators of cardiovascular health (resting heart rate, blood pressure, and fitness measures) are presented in Table 18. There was no change in resting heart rate. One subject was deleted from the blood pressure analysis due to self-initiated changes in blood pressure medication at T3 and again at T4. For the remaining 8 subjects, resting systolic blood pressure was reduced at T2, compared with T1, and remained lowered at the 2-month follow-up. Resting diastolic blood pressure remained unchanged.

Time to complete the slow-paced protocol of the self-paced stepping test was reduced at T2 and showed a further improvement at T3 that was sustained at follow-up. O_2-pulse for the slow-paced protocol was increased at T3 and sustained at T4. Perceived exertion was consistent throughout.

Time to complete the normal-paced protocol of the self-paced stepping test was reduced at T2 and remained lowered at T3 and T4. O_2-pulse for the normal-paced protocol was unchanged over time. Perceived exertion was again consistent over time.

Only 7 subjects completed the fast-paced protocol at all 4 time points. There were no changes in time to complete, O_2-pulse, or perceived exertion at any time point.

There were no changes in total VPS score over time (Table 19). Dietary data are presented in Table 20 for 8 subjects for whom data collection was complete. There were no differences between study time points. No time point differed from the original recommendations.

Only 6 subjects provided their personal blood glucose testing results. Two of the other subjects said they either did not test regularly and/or did not record the results. Another subject recorded only lists of blood glucose values with no distinction with regards to date or time, making it impossible to calculate weekly averages. Blood glucose results that were received could not be analyzed. We were unable to calculate 37% of individual weekly averages due to the frequency of missing data. There was only continuous data available on 1 subject. No pattern of change was discernable.

5.3.4 Discussion

5.3.4.1 Adherence

Subjects attended 100% of the First Step Program sessions during the adoption phase, likely a result of the very short-term commitment required. Short-term commitment to structured exercise programs in this population is likewise very good, but becomes problematic over the long-term (Ecclestone et al., 1998; Schneider et al., 1992).

As noted, two other studies have reported using pedometers to monitor adherence to daily activity for 4 weeks (Meshkinpour et al., 1998) and 6-8 weeks (Yamanouchi et al., 1995). Published pedometer results (either in distance traveled or steps/day) for the duration worn were presented previously (see Table 2). Ours is the first study we are aware of, however, to examine pattern of change in physical activity in the form of steps/day recorded for 8 continuous weeks. This is also the first pedometer-based study to do a short-term follow-up, post-intervention with no interim contact or pedometer supplied.

Relapse in exercise behaviour is considered especially problematic for individuals with Type 2 diabetes (Krug et al., 1991; Swift et al., 1995). There was an apparent decrease in steps/day over the three days of Christmas holidays that was not statistically significant. From the perspective of patterns of physical activity, it is noteworthy that, left on their own with only their pedometers for reinforcement, subjects spontaneously returned to higher steps/day after the holidays. They appeared to have dealt with this high-risk situation for relapse successfully.

5.3.4.2 Mediating processes

The DSES has been described as an acceptable instrument for assessing diabetes self-care self-efficacy (Padgett, 1991). It is a copywritten instrument (M.K. Crabtree, personal communication) that has never been published, except in dissertation form (Crabtree, 1986). Observationally, subjects expressed frustration with the instrument, especially in regards to its negatively worded format (e.g., I can't exercise because I don't know how much exercise is safe for me). Subjects' frequent preferences for the non-applicable category resulted in a great deal of missing data, precluding statistical analysis. For the subcategories we were able to collect complete data on, the mean values were not different from those recorded during the development and preliminary testing of the DSES (Crabtree, 1986).

In addition to the instrument described above, we attempted to use our own questions to describe changes in mediating variables over time. Perceived importance of exercise was sensitive to change with the First Step Program. Importantly, this value was low at baseline, increased immediately and was sustained over time. Self-reported stage of change, a reflection of intention, tended to increase as well from T1. "Stick to it" confidence, and confidence in the number of days able to attain a self-selected goal, although displaying a decreasing trend with time away from the intervention, did not change over time statistically. Neither of these last two methods of assessing self-efficacy could be assessed at baseline because both required specific knowledge of the First Step Program.

Questions designed to get at outcome expectations did not change over time either. These values were consistently high through out the study; optimism for outcomes was high from the beginning and was not sensitive to change. Glasgow et al. (1989) has previously reported that individuals with Type 2 diabetes perceive regular exercise to be beneficial, regardless of their actual participation behaviours.

During the adoption phase of the First Step Program, participants were steadily increasing their goals by self-selected increments. As they inevitably moved towards a ceiling or sustainable value, their absolute amounts of incremental increases naturally decreased. During the adoption phase, a great deal of support from various sources likely contributed to the high weekly attainment of goals. As time progressed away from the group sessions, goal attainment was decreased, however, this was tabulated in relation to the peak goal set the final week of the adoption phase. It is important to note that although the number of days when this peak goal was attained deteriorated during the adherence phase, average physical activity remained elevated from baseline.

5.3.4.3 Outcomes

The pattern of increased physical activity, which deteriorates over time and with reduced contact, is a typical observation in intervention studies (Hillsdon & Thorogood, 1996). The First Step Program elicits an immediate and large increase in steps/day, and although this drops off over time, there is evidence to suggest that physical activity remains higher compared to baseline, even after two months of no contact and no pedometer reinforcement. The calculated effect size (Kazis, Anderson, & R.F.Meenan, 1989), based on T1 and T4 means and the T1 standard deviation, is 1.1. Cohen (Cohen, 1977) suggests than any effect size greater than 0.8 is large. The average improvement in steps/day was greater than the baseline standard deviation. When converted to minutes at T4, participants in the First Step Program come close to public health recommendations (US Surgeon General, 1996).

The peak mean value of steps/day achieved at T2 (10,115 steps/day) is much lower than for a previously published hospital-based population (19,200 steps/day; (Yamanouchi et al., 1995). In our own study, subjects set their own goals, whereas in the study by Yamanouchi et al., hospital-based patients were given the directive to accumulate at least 10,000 steps/day. These patients obviously were able to over-shoot this goal easily while in the hospital. The values we found are more reflective of a free-living population. A direct comparison to the study conducted by Meshkinpour et al. (Meshkinpour et al., 1998) is not possible because their results were presented in miles traveled per day.

In the present study, a great deal of trust was placed in subjects' ability to blind themselves to their pedometer results at each of the major assessment points. There was evidence of stickers having been in place for the duration of the assessments (soiled and/or worn at the edges). Observationally, these subjects appeared to fully understand and appreciate the rational for the blinding procedure. This may not be the case, however, for special populations, including children and older adults with dementia.

The intraclass correlation coefficient we obtained for test-retest pedometer values is slightly higher than previously reported in a sample of patients with peripheral claudication tested over two days (ICC=0.91 vs. ICC=0.86; (Sieminski et al., 1997). Sieminski et al. also reported a wider variance in steps/day than what we recorded (5,500 compared with 3,500 steps/day), suggesting that physical activity behaviour was uniformly slightly more stable in our sample.

It may be argued that subjects, albeit blinded to their pedometer results during the 3-day assessment period at each major time point, were aware of the pedometer they wore and altered their behaviour accordingly. Concomitant changes in indicators of cardiovascular fitness and waist girth provide additional support of a true sustained change in physical activity levels.

For the most part, energy expenditure determined from the activity log was similar to both previously published values (Bouchard et al., 1983) and to values we recorded in a predominantly non-diabetic sample of middle-aged adults recruited for a variety of activity levels (see Chapter 3). The one exception noted was obtained at T3. Closer scrutiny revealed that at that time, 5 of the 9 subjects recorded periods of snow shoveling (category 7 on the activity log) that no subject recorded at any other time point. Except for this one obvious activity artifact, the activity log was not able to pick up increased activity levels at any time point, despite the fact that an objective measure indicated that such an increase did occur. Although activity logs and other records are considered direct measures of physical activity levels (Ainsworth et al., 1998), the version we used was most sensitive to sudden increases in vigorous activity but lacked sensitivity to apparent changes in walking behaviour.

There were no changes in either of the indicators of physical inactivity that we examined. This is not suprising, since the intervention did not specifically attempt to reduce these behaviours. As far as we know, we are the first to separately present a category of sitting derived from an activity log. Therefore no comparisons can be made at this time. Regarding television viewing, the values we obtained are not different from those recorded in an adult Pima Indian population (Fitzgerald et al., 1997) and low income women (Jeffery & French, 1998). Adults who watch 3-4 hours/day of television are considered moderately frequent viewers (Tucker, 1990). Television viewing and exercise duration have been significantly and inversely related (Tucker, 1993). The fact that we saw no change in television viewing habits or sitting behaviours, despite an objectively measured increase in physical activity, may suggest that: 1) such self-reported inactivity behaviours may suffer from the same problems as self-reported physical activity behaviours; and/or, 2) such behaviours are relatively stable and impervious to changes in activity. We can also deduce that any previously reported association between television viewing and exercise (Tucker, 1993) is not a result of a cause and effect relationship.

Reductions in abdominal adiposity (evaluated by magnetic resonance imaging; MRI) with no changes in body weight have been previously reported for individuals with Type 2 diabetes involved in an intense training program two times per week, and intermittent exercise once a week, for two months (Mourier et al., 1997). There were no reported changes in waist girth. Walker et al. (1999) reported decreases in waist region fat content (assessed by dual-energy X-ray absorptiometry; DXA) after 12 weeks of 60 minutes of walking, 5 days a week in women with Type 2 diabetes, but no changes in waist girth. The average waist girth of the participants at the beginning of the First Step Program was 10-16 cm more than either of these two studies (98 cm and 92 cm, respectively). This discrepancy is not a result of differences in measurement protocols; the First Step Program participants' weight averaged 94kg, compared with 85kg and 78kg, respectively.

Lehman et al. (1995) reported improvements in percent body fat and waist to hip ratio in individuals with Type 2 diabetes, also independent of any change in body weight, with a 3-month moderate exercise training program. In our study, the trend for reduced hip girth did not reach statistical significance, however, it likely contributed to the fact that waist to hip ratio remained constant despite the significant reductions observed in waist girth. Waist circumference is a better index of abdominal visceral adiposity (assessed by computed tomography) than waist to hip ratio (Pouliot et al., 1994). Waist and hip circumferences, but not waist to hip ratio, are independently associated with reductions in body fat assessed by MRI (van der Kooy et al., 1993). Weight loss over 1 year in individuals with Type 2 diabetes has been associated independently with waist and hip girths in both men and women, but only with waist to hip ratio in men (Pascale, Wing, Blair, Harvey, & Guare, 1992).

Resting heart rate did not change, likely due to the lack of controlled intensity of physical activity undertaken. Improvements in resting heart rate in individuals with Type 2 diabetes have been previously reported following participation in moderate to vigorous intensity structured training programs (Lehmann et al., 1995; Raz et al., 1994). Observed changes in systolic blood pressure in participants in the First Step Program were immediate and notable (effect size=0.66, or moderate; (Cohen, 1977), and similar to improvements reported by Wing et al. (1988) reporting concomitant weight loss, and Lehman et al. (1995) reporting no change in body weight. Both of these studies also reported reductions in diastolic blood pressure, which we did not observe in our sample. Both of these studies also featured structured training programs with specific guidelines for duration and frequency of activities undertaken, whereas the First Step Program permited participants to set goals and monitor their own progress. Other walking-based programs in this population (Walker et al., 1999; Yamanouchi et al., 1995) have not reported program impact on these outcomes. The changes we noted are important: the UK Prospective Diabetes Study (UK Prospective Diabetes Study Group, 1998a) has shown that intensive blood pressure control using pharmaceutical agents in individuals with Type 2 diabetes results in reduced fatalities due to myocardial infarction and stroke.

We selected a relatively new measure of cardiorespiratory fitness to meet our specifications of a clinically applicable, feasible and acceptable submaximal test. The test requires minimal equipment (2-tier step, stopwatch, and stethoscope), takes up little space (the step is able to fold-up when not in use), and, as previously indicated, it has been shown to be easily delivered by both trained and untrained assessors with similar results (Petrella et al., 1998).

Intraclass correlation coefficients were generally high for test-retest reliability of the self-paced step test with the exception of the fast-paced time to complete. Although this variable was not repeatable, fast-paced O_2-pulse, calculated from multiple variables, was repeatable. This suggests that once the workload was considered, physiological response was consistent over time, regardless of preferred pace of performance.

The consistency of ratings of perceived exertion over time increases our confidence in the self-paced step results; subjects perceived similar workloads, yet objective measures generally indicated improvements in performance. Subjects perceived the slow-paced protocol as "weak" to "moderate", the normal-paced protocol as "somewhat strong" to "strong", and the fast-paced protocol as close to "very strong" (Borg, 1982). The slow-paced protocol appeared to be most sensitive to improvement with intervention, likely due to specificity of training. At no time were subjects given any directive about intensity of physical activity to be undertaken; they were only encouraged to proceed at their own pace. Time to complete the normal-paced protocol showed change over time, and although there was an apparent trend for improvement in the calculated physiological response index, O_2-pulse, it was not statistically significant. Our choice of the Greenhouse-Geisser epsilon for adjusting degrees of freedom is considered a conservative test, especially in small sample sizes (Winer, 1971). None of the variables measured for the fast-paced protocol changed.

Recently, Walker et al. (1999) reported the results of a regular walking program in women with Type 2 diabetes. They estimated VO_2 *max* from heart rate (monitored during a timed 1 mile walk) using a prediction equation developed in a healthy adult population (Kline et al., 1987) and were able to demonstrate a 16.5% improvement in cardiorespiratory fitness with 12 weeks of walking. Self-paced step test results can be used to predict maximal aerobic capacity in healthy older individuals (Petrella et al., 1998), and expressed as VO_2 *max*, the test has been shown to be sensitive to a physician-driven intervention (Petrella & Wight, 1999). We decided, however, that it was not useful to present our step-test results as VO_2 *max* in this population using an equation developed in a different population. Individuals with Type 2 diabetes have a compromised aerobic capacity (Katoh et al., 1996; Regensteiner et al., 1995; Schrier et al., 1996; Wei et al., 1999) and improvements due to training are less than that observed in sedentary nondiabetics (Schneider et al., 1992). The results of Walker et al. (1999) are somewhat questionable in this light. The validity of the self-paced step test needs to be assessed relative to a standardized test of maximal aerobic capacity in individuals with Type 2 diabetes. Prediction equations for VO_2 *max* specific to this population can then follow.

VPS values we obtained are similar to those previously reported in obese (35.0) and in diabetic samples (35.6) and lower than for a middle-aged sample with no apparent health problems (40.7) (Myers et al., in press). Trends for change that appeared to follow pattern of physical activity were not statistically significant in this small sample size. Based on the T1 standard deviation and the observed change from T1-T4, a sample size of 147 would be needed to detect a significant change at $p<.05$ and a power of 80% (Armitage & Berry, 1987).

Energy intake due to protein was relatively stable over time (18-19%) and was within recommended ranges (Canadian Diabetes Association, 1989). Energy intake due to dietary fat ranged from 30-41% in this sample, generally higher than recommended levels (Canadian

Diabetes Association, 1989). Individual subjects reported occasionally eating at fast-food restaurants and their dietary fat levels were likely a reflection of their choices.

All of the subjects had been given dietary recommendations for reducing body weight as part of their earlier diabetes education, as can be seen from the relatively low values of prescribed energy intake. Reported values did not differ from the original recommendations at anytime point. There was no change in body weight over the course of the study, although there was objective evidence of increased physical activity. These contradictory findings suggest that the dietary data collected is untrustworthy. There are limitations to self-reported dietary intake; obese individuals can underestimate intake by as much as 50% (Schoeller, 1995).

Caution must be used when interpreting these data for other reasons as well. There was a very great interindividual variability in dietary variables, as can be seen in both the large standard deviations and the wide 95% CIs for the mean values at each time point and with respect to the original recommendations obtained from patient charts. We found evidence suggesting the quality of the interviews was suspect. Compounding this problem was the fact that initial data was collected by one interviewer, who was then replaced by a second interviewer to collect the final data points. We are, therefore, not confident with drawing any conclusions about dietary intake in this study.

The inadequate data collected on blood glucose monitoring was particularly frustrating, but not surprising. The prevalence of low levels of adherence to self-monitoring blood glucose has produced a relatively new area of behavioural research (Glasgow et al., 1997; Jones, Remley, & Engberg, 1996; Wing, Epstein, Nowalk, Scott, & Koeske, 1985). Barriers to self-monitoring blood glucose include guilt, procrastination, inconvenience, cost, and denial of diagnosis (Jones et al., 1996). In addition to non-compliance issues, user errors and falsification of data are important sources of error in interpreting logs of self-monitored blood glucose (Kilpatrick, 1997). A more objective approach to assessing glycemic control as a result of participation in the First Step Program is necessary.

5.3.5 Conclusions

This summative evaluation represents a sequential step in a systematic program evaluation process (Myers, 1999) designed to provide direction to the implementation, operation, modification, and continuation of the First Step Program. Based on our experiences we are able to make a number of recommendations for program delivery and for improved evaluation of this and similar physical activity interventions.

Although promising results are noted with participation in the First Step Program, the lack of a control group is the most important limitation to drawing firm conclusions and this will be addressed in a subsequently planned randomised controlled trial. Although the sample size evaluated in this preliminary sample is arguably small, the very large effect sizes expected for increased physical activity, measured objectively as steps/day, indicates that sample sizes in the order of 26 are adequate (Cohen, 1977) for subsequent trials.

Pedometers present an acceptable and feasible way of objectively and continuously monitoring physical activity patterns, or adherence to daily physical activity goals, in populations where walking behaviours are the most prevalent expression of physical activity. Using this methodology we can explore factors related to total daily physical activity adoption, adherence, and relapse. No other comparable approach is currently available. The closest alternative, accelerometers, are more expensive and less user friendly. Although their use has become more frequent in physical activity epidemiology, it makes the most sense to use the same instrumentation to both evaluate and intervene. Pedometers have been too quickly rejected by researchers because of earlier mechanical problems that have been rectified (Bassett et al., 1996) and flawed approaches to expressing reliability (Tryon et al., 1991).

On the other hand, we found that an activity log, a typical technique use to document adherence to physical activity recommendations, was not sensitive to objectively determined, and substantial, increases in walking behaviours. Therefore, this particular measure is not useful for evaluating changes in physical activity as a result of walking-based physical activity interventions. Likewise, self-reported indices of inactivity were unresponsive to the First Step Program and such questions can not be used as a proxy indicator of changing physical activity levels.

The self-paced stepping test was selected as an outcome measure of cardiorespiratory fitness primarily because of its feasibility; our intention was to make both the program and its evaluation practical for clinical applications. We recommend, however, that future evaluations include only the slow- and normal-paced protocols. In addition to not being sensitive to change, not everyone was able to complete the fast-paced protocol and the reported ratings of perceived exertion suggest that the subjects were under going unnecessary stress. We do need to validate self-paced step performance with measures of VO_2 *max* in individuals with Type 2 diabetes.

The assessment of body composition is important to drawing conclusions about cardiovascular risk in this population. Future evaluations of the First Step Program should focus on measures of waist girth and hip girth, and forego calculation of a waist to hip ratio. Although weight did not change despite objectively determined increases in physical activity, obesity is a typical problem and therefore we need to continue to monitor body weight. Energy intake is an obvious confounder and additional efforts need to be taken to increase the trustworthiness of dietary data collected, including standardized and consistent interviewing approaches. Although important, dietary interviews are limited. Further research needs to compare the First Step Program to a combined diet and First Step Program.

It is also important to continue to evaluate the impact of glycemic control. Accessing blood glucose monitors with internal memory will resolve user errors, but subjects must still remember to regularly assess their blood glucose levels. Instead, we intend to wait to draw conclusions based on laboratory measures of glycemic control (fasting blood glucose, OGTT, HbA_{1C}) in a subsequently planned randomised controlled trial.

An adequate instrument does not currently exist to assess diabetes self-care self-efficacy, or specifically, physical activity self-efficacy, in this population. The importance of exercise and stage of change can be used to assess changes in attitudes and intentions, respectively. Adherence confidence questions show apparent changes in patterns only after program entry. High outcome expectations may be characteristic of subjects willing to participate in physical activity interventions. Physical activity outcome expectations are high and stable, which may be a unique characteristic of participants. Outcome expectations need to be assessed in individuals who decline participation in the First Step Program or other similar interventions for comparison purposes.

In conclusion, the theory-based First Step Program is a promising daily physical activity intervention for individuals with Type 2 diabetes. The Canadian Diabetes Association has funded a randomised controlled trial currently underway which will allow us to draw firmer conclusions about the program's impact. If the results of this next study are positive and replicate the findings the present pilot, we will move quickly towards dissemination of the First Step Program. The ultimate goal is to provide clinicians, educators, and most importantly, individuals with Type 2 diabetes themselves, with a feasible and acceptable approach to increasing physical activity.

Tables

Table 1: Pedometer values for free-living populations

Study	Subjects	Age (years)	Monitoring Frame	Average Steps/days
Kashiwazaki et al. (1986)	10 clerical workers	37.7±8.6	1 weekday	10,571±4,336*
Kashiwazaki et al. (1986)	13 assembly workers	35.2±8.5	1 weekday	11,294±2,336*
Bassey et al. (1987)	11 medical school workers (5 male, 6 female)	29±9.5	10 consecutive days	10,793±3,553*
Bassey et al. (1987)	24 female fitness class participants	67±6.4	6 consecutive days	6,417±2,800*
Bassey et al. (1988)	56 males, 66 females	M: 71±4 F: 72±4	1 week	M: 7,142±3,857* F: 6,000±4,000*
Cowley et al. (1991)	12 with chronic heart failure (11 males)	56	1 week	3,700±514*
Voorrips et al. (1991)	A subsample of 30 from convenience sample of 90 drawn from rec centres, clubs, interest	Larger sample: 63-80	3 consecutive days (1 weekend day)	7,335±4,369
Tryon et al. (1992)	127 females range of weights	19-55	14 consecutive days	7,163±2,899*
Sequeira et al. (1995)	265 males 228 females	25-74	1 week	M 25-34: 11,900 M 65-74: 6,700 F 25-34: 9,300 F 65-74: 7,300
Ichihara et al. (1996)	Japanese, 282 males, 231 females	40-60	1 week	M:8,107±2,922 F:7,762±3,301
Walsh et al.(1997)	74 males, 10 females with chronic heart failure	46-78	1 week	3,571*
Gardner et al. (1997)	34 male smokers with claudication 43 male nonsmokers with claudication	63.9±9.2 67.8±5.9	2 consecutive weekdays	4,116±2,199 5,329±2,924
Schmalzried et al. (1998)	111 joint replacement patients	58.6	1 week	<60: 5,732 ≥60: 4,400 M: 5,579 W: 4,364 M<60: 6,433 Hip: 5,194 Knee: 3,514

Note: Values are means±SD where possible. M=males, F=Females. * Steps/day calculated from information presented in the article.

Table 2: Interventions using pedometers

Study	Subjects	Intervention	Pedometer Values (steps/day)	
			Pre	Post
Bassey et al. (1983)	56 factory workers 55-60 years	12 week unsupervised, progressive walking program (no pedometer during program)	11,000±600	12,700±600
Yamanouchi et al. (Yamanouchi et al., 1995)	Obese hospital-based patients with Type 2 diabetes 14 Diet+ Physical activity 10 Diet Only	6-8 weeks Diet+Physical activity: Pedometer and instruction to get 10,000steps/day Diet Only: Pedometer and instruction to maintain typical activity	No baseline values reported	Diet+Physical activity 19,200±2,100 Diet Only: 4,500±290
Meshkinpour et al. (1998)	8 consecutive patients (7 females, 1 male) with chronic constipation 50.1±16 years	4 weeks, 1 hour/day, 5 days/week at prescribed intensity (pedometer worn and log maintained)	Values reported in miles/day: 1.8±0.33	Values reported in miles/day: 3.2±0.28
Fogelholm et al., (1997)	78 obese women after a very-low-calorie diet	No exercise Walk to expend 1000kcal/week Walk to expend 2000kcal/week (no pedometer during program)	No baseline values reported	6,607 8,303 9,760

Note: Values are means±SD where possible.

Table 3: Physical activity intervention studies in Type 2 diabetes

Study Design	Subjects Therapy	Age	BMI	Diabetes duration (years)	Fasting glucose	Intervention	Physical activity	Cardio fitness	Glycemic control	Insulin sensitivity	Cardio risk	Weight loss
Hartwell 1986 random	Diet Exercise Diet+exercise Education control All therapies	?	?	?	191.4 mg/dl	F 1/week supervised 2/week unsupervised I 60-70% of max TI 50-60 min T walking 10 weeks (not exercising until third week or later) Followed at 3 months and 6 months	↑	↑	FBG Diet group ↑. Exercise group ↑. No other changes. HbA_{1c} No change in any group	?	TG ↓ CHOL ↔ LDL Only diet ↓ HDL Diet group ↑, control group ↓, no other changes significant.	Diet group lost most weight. No difference between other groups.

?=Unknown, F=frequency, I=intensity, TI=time, T=type, FBG=fasting blood glucose, HbA_{1c}=glycosylated hemoglobin, FRUC=fructosamine, OGTT=oral glucose tolerance test, FPI=fasting plasma insulin, TG=triglycerides, CHOL=total cholesterol, LDL=low density lipoproteins, HDL=high density lipoproteins, ITT=insulin tolerance test, EUGLMP=euglycemic clamp

Physical activity interventions in Type 2 diabetes (continued)

Study Design	Subjects Therapy	Age	BMI	Diabetes duration (years)	Fasting glucose	Intervention	Physical activity	Cardio fitness	Glycemic control	Insulin sensitivity	Cardio risk	Weight loss
Wing 1988 random Study 1	10 diet+exercise 12 diet +sham exercise All attended education Diet and oral therapy only	56 52	38 38	4 6	10.1 mmol/L 10.2 mmol/L	F 2/week supervised 1/week alone I ? TI 60 min T walking or light exercise 10 weeks 1 year follow-up	↑ to same degree in both Sustained over 1 year in both	?	OGTT ↓ in both HbA_{1c} ↓ in both groups Not sustained over 1 year	FPI ↓in both groups Not sustained over 1 year	TG ↓ CHOL ↓ BP ↓ Not sustained over 1 year	↓ in both groups Sustained over 1 year in both
Wing 1988 random Study 2	15 diet +exercise 13 diet All attended education All therapies	55 56	38 38	7 7	12.6 mmol/L 11.9 mmol/L	F 4/week I ? TI 60 mins T walking 10 weeks 1 year follow-up	↑ Sustained over 1 year	?	HbA_{1c} ↓ in both groups Sustained over 1 year	FPI ↓ in both groups	TG ↓ Not sustained over 1 year	Lost more in diet and exercise group

?=Unknown, F=frequency, I=intensity, TI=time, T=type, FBG=fasting blood glucose, HbA_{1c}=glycosylated hemoglobin, FRUC=fructosamine, OGTT=oral glucose tolerance test, FPI=fasting plasma insulin, TG=triglycerides, CHOL=total cholesterol, LDL=low density lipoproteins, HDL=high density lipoproteins, ITT=insulin tolerance test, EUGLMP=euglycemic clamp

Physical activity interventions in Type 2 diabetes (continued)

Study Design	Subjects Therapy	Age	BMI	Diabetes duration (years)	Fasting glucose	Intervention	Physical activity	Cardio fitness	Glycemic control	Insulin sensitivity	Cardio risk	Weight loss
Vanninen 1992 random	Education+ diet+ Exercise education Education control Therapy ?	40-60	?	All newly diagnosed	7.6 mmol/L 8.9 mmol/L	F 3-4/week I ? TI 30-60 mins T individual aerobic 15 months with 12 month follow up	↔	↔	FBG ↓ HbA_{1c}↓	?	TG ↓ CHOL ↔ HDL ↑	↓(likely due to reported diet changes)
Raz 1994 random	19 exericse 19 control Orals only All had persistent hyperglycemia	50-70	31.8 30.2	?	11.4 mmol/L 11.8 mmol/L	F 2/week supervised 1/week alone I 65-70% of max TI 50-60 min T aerobic equipment 12 weeks 1 year followup	↑ 12/19 continued exercise over year	↑	FBG ↔ HbA_{1c}↓ FRUC ↓ HbA_{1c} Continued to increase in those still exercising 1 year later	?	TG ↓ CHOL ↔ HDL ↔	↔

?=Unknown, F=frequency, I=intensity, TI=time, T=type, FBG=fasting blood glucose, HbA_{1c}=glycosylated hemoglobin, FRUC=fructosamine, OGTT=oral glucose tolerance test, FPI=fasting plasma insulin, TG=triglycerides, CHOL=total cholesterol, LDL=low density lipoproteins, HDL=high density lipoproteins, ITT=insulin tolerance test, EUGLMP=euglycemic clamp

Physical activity interventions in Type 2 diabetes (continued)

Study Design	Subjects Therapy	Age	BMI	Diabetes duration (years)	Fasting glucose	Intervention	Physical activity	Cardio fitness	Glycemic control	Insulin sensitivity	Cardio risk	Weight loss
Yamanouchi 1995 nonrandom	14 diet+physical activity 10 diet No other therapy	23-59	31.2 31.6	Diagnosed within 1 yead	?	Pedometer goal: 10,000 step/day 6-8 weeks	↑	?	?	EUCLMP ↑	?	Greater ↓in body weight in exercise condition
Lehmann 1995 nonrandom	16 exercise 13 age, sex matched controls All oral or insulin only	56	31.2	7.1	9.0 mmol/L	F 1/week supervised 2/week alone I 50-70% max effort TI 30-45min T various aerobic	↑at 3 months, stable at 6 months	↑	FBG ↔ HbA1c ↔	?	TG ↓ CHOL ↔ HDL ↑ BP ↓	Body weight ↔ WHR ↓ body fat ↓

?=Unknown, F=frequency, I=intensity, TI=time, T=type, FBG=fasting blood glucose, HbA_{1c}=glycosylated hemoglobin, FRUC=fructosamine, OGTT=oral glucose tolerance test, FPI=fasting plasma insulin, TG=triglycerides, CHOL=total cholesterol, LDL=low density lipoproteins, HDL=high density lipoproteins, ITT=insulin tolerance test, EUGLMP=euglycemic clamp

Physical activity interventions in Type 2 diabetes (continued)

Study Design	Subjects Therapy	Age	BMI	Diabetes duration (years)	Fasting glucose	Intervention	Physical activity	Cardio fitness	Glycemic control	Insulin sensitivity	Cardio risk	Weight loss
Samaras 1997 random	13 exercise+ eduction 13 standard education	60	32.3	?	9.3 mmol/L	F 1/month I able to speak comfortably T ? T aerobic 6 months with 12 month follow-up	↔	?	FBG ↔ HbA1c ↔ at 6 months, ↓ at 12 months	?	TG ↔ CHOL ↔ HDL ↔	↔
Ligtenberg 1997 random	30 exercise 28 education All oral or insulin only	62	30.8 31.2	6.6 9.4	?	F 3/week I 60-80% of VO_2max (HR) TI 60 minutes T aerobic equipment 6 weeks supervised, 6 weeks contact, 14 weeks no contact	↑ after 6 weeks and after 26 weeks	↑	FBG ↔ HbA1c ↔	ITT ↔	TG ↓ CHOL ↓ LDL ↔ VLDL ↓ HDL ↔ All changes gone by 26 weeks	↔
Walker 1999 nonrandom	11 exercise Diet and oral only	58	31.1	3, newly diagnosed 8, 2.7±2.8	?	F 5/week I self-paced TI 60 minutes T walking 12 weeks	?	↑	FBG ↓ HbA1c ↓	?	CHOL ↓ LDL ↓ HDL ↔	BMI ↓ Body comp improved

?=Unknown, F=frequency, I=intensity, TI=time, T=type, FBG=fasting blood glucose, HbA_{1c}=glycosylated hemoglobin, FRUC=fructosamine, OGTT=oral glucose tolerance test, FPI=fasting plasma insulin, TG=triglycerides, CHOL=total cholesterol, LDL=low density lipoproteins, HDL=high density lipoproteins, ITT=insulin tolerance test, EUGLMP=euglycemic clamp

Table 4: Leisure time activity by occupational tasks

Variable	Low intensity work tasks (*n*=39)	Moderate intensity work tasks (*n*=11)	t	*p*
MAQ Leisure Time Hours/week				
With walking	4.5±3.7	2.3±2.3	1.879	.066
Without walking	2.8±3.0	1.9±1.9	0.970	.337
MET-hours/week				
With walking	19.2±15.7	9.7±8.5	1.934	.059
Without walking	13.2±14.5	8.1±7.5	1.129	.265

Note: values are mean ±SD. 95% CI are inappropriate for this measure due to a floor effect of zero.

Table 5: MAQ total physical activity and leisure physical activity

MAQ variable	Inactive (*n*=13)	Irregularly active (*n*=15)	Regularly active (*n*=22)	F	*p*
Total physical activity Hours/week With walking	6.8± 9.2	10.0±11.9	8.9±7.5	0.405	.669
Without walking	5.0±9.8	9.5±11.9	7.1±7.9	0.749	.478
MET-hours/week With walking	27.3±37.4	40.3±46.8	37.7±30.3	0.464	.632
Without walking	20.9±39.6	38.5±46.6	31.2±32.2	0.711	.496
Leisure physical activity **Hours/week** **With walking**	2.8±3.3^a	2.7±2.1^a	5.7±4.3^b	4.751	.013*
Without walking	1.1±1.0^a	2.2±1.8^{a,b}	3.8±3.6^b	4.725	.014*
MET-hours/week **With walking**	11.5±8.8^a	11.0±7.6^a	24.6±18.1^b	5.998	.005*
Without walking	5.1±5.3^a	9.2±6.9^a	18.1±17.1^b	5.129	.010*

Note: values are mean ±SD.95% CI are inappropriate for this measure due to a floor effect of zero.

*** p<.05, **p<.01, shared superscripts (a,b) denote similarities between groups**

Table 6: Indicators of current activity

Variable	*n*	Inactive	*n*	Irregularly active	*n*	Regularly active	F	*p*
Activity log	13		15		22			
Activity energy expenditure (kcal/kg/day)		43.5±4.3 (40.9-46.1)		45.3±4.7 (42.7-47.9)		45.2±6.2 (42.4-47.9)	0.490	.616
Time in moderate-high intensity activities (hours)		0.5±0.5 (0.3-0.8)		1.0±1.1 (0.4-1.5)		1.2±0.9 (0.8-1.6)	2.715	.077
Heart rate monitor	9		11		15			
Average heart rate (bpm)		83.8±9.8 (76.3-91.4)		83.9±7.4 (78.9-88.9)		84.8±8.4 (80.1-89.4)	0.167	.847
Activity energy expenditure (kcal/kg/day)		40.4±10.1 (32.6-48.2)		40.9±12.4 (32.6-49.2)		42.0±10.0 (36.5-47.6)	0.071	.931
Pedometer	13		14		21			
Counts/steps		12,588±6,851 (8,448-16,727)		13,380±6,371 (9,702-17,059)		13,583±6,089 (10,811-16,354)	0.101	.904
Distance (km)		8.3±4.1 (5.8-10.8)		9.6±4.5 (7.0-12.2)		9.1±4.2 (7.2-11.0)	0.295	.746

Table 7: Indicators of inactivity

Inactivity variable and sources	*n*	Inactive	*n*	Irregularly active	*n*	Regularly active	F	*p*
	13		15		22			
Hours TV viewing (MAQ)		2.6±2.1 (1.7-3.5)		2.4±1.1 (1.8-3.1)		2.0±1.2 (1.4-2.5)	1.17	.320
Hours sitting at work (MAQ)		5.4±2.1 (4.1-6.6)		4.1±1.9 (3.1-5.1)		5.0±2.3 (4.0-6.0)	1.399	.257
Hours sitting during day (Log)		8.0±1.8 (6.9-9.1)		6.3±2.3 (5.0-7.5)		(7.3±2.4 (6.2-8.4)	2.12	.131

Table 8: Task analysis - Increasing physical activity using pedometers

Cognitive	Psychomotor	Affective
Knows the benefits of becoming more active	Able to reset and attach pedometer	Has a high task self-efficacy ("stick-to-it-ness")
Knows baseline # of steps	Able to regularly check values	Values a variety of physical activity behaviours
Knows # of steps in timed walk	Able to initiate behaviour change based on pedometer feedback	Able to overcome guilt associated with relapse
Knows social support can help	Able to record daily steps on calendar	
Knows daily steps goals	Able to calculate progress (# of days goal met, total number of steps, average daily steps)	
Knows the effect of different activity behaviours on # of steps taken		

Table 9: Cognitive learning objectives

Given…	The learner will…	To the extent that…	As evaluated by…
Opportunity for reflection and small group discussion	Identify gains and losses to oneself and others if physical activity increases	Gains outweigh the losses	Themselves
Individualized feedback	State their baseline steps/day	It is written on their weekly goal-setting worksheet	By a roaming intervener
An opportunity for a timed walk	State the number of steps taken in the time frame	It accurately reflects the values posted by the pedometer	By a roaming intervener
A lecturette on strategies and small group discussions	Identify strategies for increasing physical activity	They describe 1-2 strategies that fit into their unique lifestyle	Their peers/intervener
A lecturette on social support strategies and small group discussions	Identify strategies for engaging others' help in increasing physical activity (social support)	They identify at least one person they will include in their behaviour change	Their peers/intervener
A lecturette on volume of physical activity, normative data, knowledge of steps taken in timed walk, and consideration of their own baseline values and unique lifestyle	Set a new daily goal in steps/day for the next week	It is specific, measureable, attainable, realistic	Themselves
A week of practice wearing the pedometer and recording their daily values	Able to explain differences in values by specific differences in physical activity behaviours	Both sedentary and active behaviours are identified and described	Their peers/intervener

Table 10: Psychomotor (skills) learning objectives

Given…	The learner will…	To the extent that…	As evaluated by…
Instruction, demonstration, practice and feedback	Reset the pedometer to zero and attach it properly to their waist	It is between the navel and hip (on either side)	By roaming intervener
Instruction, practice and feedback	Regularly check pedometer values	They identify what they were doing when they remembered to check it	Their peers/intervener
Instruction, practice and feedback	Initiate behaviour change based on pedometer values	They describe such behaviour	Their peers/intervener
Instruction, practice and feedback	Initiate behaviour change based on pedometer values	They describe such behaviour	Their peers/intervener
Instruction, demonstration, practice and feedback	Record daily values on their calendars	Records are clear, no data is missing, days when goals are achieved are checked	
Instruction, demonstration, practice and feedback	Calculate progress	# of days goals achieved, total weekly steps, and average daily steps are identified	Their peers/interveners

Table 11: Affective (attitude) learning objectives

Given...	The learner will...	To the extent that...	As evaluated by...
A lecturette on volume of physical activity, normative data, knowledge of steps taken in timed walk, and consideration of their own baseline values and unique lifestyle	Indicate a high self-efficacy score on their weekly goal setting sheet	They score themselves greater than 60% for stick-to-it-ness And Are confident they will achieve their goals on at least 3/7 days per week	Roaming intervener
A lecturette on volume of physical activity, normative data, knowledge of steps taken in timed walk, and consideration of their own baseline values and unique lifestyle	Verbalize opportunities for increased physical activity	Opportunties are identified during work, chores, and leisure time	Their peers/intervener
A lecturette on relapse and small group discussion about their own experiences	Able to identify high-risk situations and strategies to deal with them	Little guilt is expressed and strategies are specific measureable, attainable and realistic	Their peers/interveners

Table 12: Test-retest reliability of self-paced step test

Variables	*n*	Test Period 1	Test Period 2	*p*	ICC
Slow time (seconds)	5	114±26 (81-147)	112±20 (87-137)	.74	0.90
O_2-pulse (ml/beat)		8.9±1.8 (6.6-11.1)	8.6±1.9 (6.2-11.0)	.72	0.78
Normal time	5	88±14 (71-105)	91±21 (65-116)	.53	0.88
O_2-pulse		9.2±2.1 (6.6-11.8)	8.8±2.0 (6.4-11.3)	.29	0.97
Fast time	3	68±7 (52-85)	63±2 (59-67)	.37	0.41
O_2-pulse		10.7±1.0 (8.8-12.6)	11.0±1.2 (8.2-14.0)	.46	0.85

Note: values are mean ±SD (95% CI)

Table 13: DSES results at repeated time points

Measure	T1	T2	T3	T4
Diabetes Self-Efficacy Scale				
Diet self-efficacy	(*n*=6) 33.0±9.9 (22.6-43.4)	(*n*=6) 35.2±9.5 (25.2-45.2)	(*n*=6) 36.3±8.4 (27.6-45.1)	(*n*=8) 36.0±6.4 (31.0-41.3)
Exercise self-efficacy	(*n*=6) 24.0±3.5 (20.3-27.7	(*n*=7) 30.0±2.3 (27.5-31.7)	(*n*=5) 28.0±3.2 (24.0-28.1)	(*n*=6) 27±4.5 (22.2-31.7)
General self-efficacy	(*n*=7) 18.6±4.8 (14.1-23.0)	(*n*=7) 22.4±1.7 (20.8-24.0)	(*n*=8) 19.0±4.4 (15.3-22.7)	(*n*=7) 18.1±4.5 (14.0-22.3)

Note: values are mean±SD (95% CI)

T1= baseline, T2=after one month of group meetings and individual practice, T3=after a further month of individual practice and limited telephone contact

T4= 2 months post-intervention and having returned pedometers to study centre.

Table 14: Case summaries of stages of change at repeated time points

Case	T1	T2	T3	T4
A	2	4	4	4
B	4	3	4	5
C	3	4	4	4
D	3	4	4	3
E	3	4	4	4
F	3	4	6	4
G	3	4	4	4
H	3	3	3	5
I	3	4	4	4

**Note: 1=Precontemplation, 2=Contemplation,
3=Preparation, 4=Action, 5=Maintenance, 6=Relapse**

Table 15: Physical activity outcome expectations at repeated time points

Measure (*n*=9)	T1	T2	T3	T4	F	*p*
Blood glucose confidence	82.2±15.6 (70.2-94.2)	88.9±7.8 (82.9-94.9)	91.1±9.3 (84.0-98.2)	90.0±8.7 (83.3-96.7)	1.469	.263
Weight loss/ maintenance confidence	92.2±12.0 (83.0-101.5)	91.1±9.3 (84.0-98.2)	92.2±8.3 (85.8-98.6)	93.3±8.7 (86.7-100.0)	0.120	.920
Avoid complications of diabetes confidence	83.3±19.4 (68.5-98.2)	91.1±7.8 (85.1-97.1)	93.3±11.2 (84.7-102.0)	91.1±7.8 (85.1-97.1)	1.928	.189

Note: values are mean±SD (95% CI)

T1= baseline, T2=after one month of group meetings and individual practice, T3=after a further month of individual practice and limited telephone contact

T4= 2 months post-intervention and having returned pedometers to study centre.

Table 16: Indicators of physical activity and inactivity at repeated time points

Measure(*n*)	T1	T2	T3	T4	F	*p*
Pedometer (9) Steps/day	6,342±2,244 (4,617-8,068)	10,115±3,407*** (7,497-12,735)	8,939±2,760** (6,817-11,061)	8,830±2,772* (6,699-10,962)	6.415	.006
Activity log (9) Kcal/kg/day	45.5±7.1 (40.0-50.9)	45.3±4.9 (41.5-49.0)	58.8±3.1† (56.5-61.2)	42.6±4.0 (39.4-45.6)	25.711	.000
Hours sitting	6.7±2.6 (4.7-8.6)	6.9±1.8 (5.6-8.3)	6.6±2.5 (4.7-8.5)	6.7±3.3 (4.2-9.2)	0.071	.946
Hours TV viewing (9)	3.9±3.1 (1.5-6.4)	3.4±2.8 (1.3-5.6)	3.5±2.1 (1.9-5.1)	3.9±2.4 (2.1-5.7)	0.711	.494

Note: values are mean ±SD (95% CI)

T1= baseline, T2=after one month of group meetings and individual practice, T3=after a further month of individual practice and limited telephone contact, T4= 2 months post-intervention and having returned pedometers to study centre, *significantly different from T1, $p<.05$, ** significantly different from T1, $p<.01$, *** significantly different from T1, $p<.001$, † significantly different from all other time points, $p<.001$

Table 17: Anthropometric measures at repeated time points

Measure (*n*)	T1	T2	T3	T4	F	*p*
Weight (9)	94.0±18.0 (80.0-107.9)	93.2±18.1 (79.2-107.1)	93.7±18.0 (79.8-107.5)	93.2±18.7 (78.9-107.6)	1.229	.318
Waist girth (9)	107.7±9.9 (100.0-115.4)	105.3±10.72* (97.1-113.57)	103.3±10.7**† (95.1-111.6)	103.3±10.8** (95.0-111.6)	8.568	.005
Hip girth (9)	115.3±10.4 (107.4-123.3)	114.7±9.7 (107.2-122.2)	114.1±9.1 (107.1-121.0)	112.4±8.8 (105.6-119.2)	3.245	.069
Waist to hip ratio (9)	0.94±0.01 (0.87-1.01)	0.92±0.01 (0.85-0.99)	0.91±0.01 (0.84-0.97)	0.92±0.01 (0.87-0.96)	2.179	.155

Note: values are mean±SD (95% CI)

T1= baseline, T2=after one month of group meetings and individual practice, T3=after a further month of individual practice and limited telephone contact, T4= 2 months post-intervention and having returned pedometers to study centre, *significantly different from T1, $p<.05$, **significantly different from T1, $p<.001$, †significantly different from T2, $p<.01$

Table 18: Indicators of cardiovascular health at repeated time points

Measure (*n*)	T1	T2	T3	T4	F	*p*
Resting heart rate (bpm) (9)	73.8±11.7 (64.8-82.8)	71.6±12.4 (62.0-81.1)	72.0±7.5 (66.3-77.8)	72.0±7.5 (66.3-77.8)	0.257	.791
Resting systolic BP (mmHg) (8)	139.3±15.7 (126.1±152.4)	129.5±12.4*** (119.2-139.8)	129.5±10.6*** (120.7-138.3)	128.8±10.3* (120.2-137.3)	4.995	.020
Resting diastolic BP (mmHg) (8)	86.3±14.1 (74.5-98.0)	80.5±10.0 (72.1-88.9)	83.8±6.5 (78.4-89.1)	80.5±11.35 (71.0-90.0)	2.292	.119
Self-paced step						
Slow time (seconds) (9)	124.4±49.7 (86.3-162.6)	106.9±35.7* (79.5-134.3)	98.8±36.6*† (70.6-126.9)	92.6±27.4*† (71.6-113.7)	9.915	.004
O_2-pulse (ml/beat)	8.9±2.7 (6.8-10.9)	9.9±3.7 (7.1-12.8)	10.7±3.2** (8.2-13.2)	10.8±4.5** (7.4-14.3)	5.089	.034
Perceived exertion	2.6±1.0 (1.8-3.3)	3.0±1.3 (2.0-4.0)	2.3±1.1 (1.5-3.2)	2.7±1.6 (1.4-3.9)	0.655	.534
Normal time (9)	90.6±22.4 (109.6-130.4)	84.3±24.6* (65.5-103.2)	81.8±21.9* (65.0-98.6)	81.2±23.8* (63.0-99.5)	3.538	.040
O_2-pulse (ml/beat)	9.6±2.8 (7.5-11.7)	10.7±4.0 (7.6-13.8)	10.8±3.1 (8.4-13.2)	10.7±4.1 (7.6-13.9)	2.469	.121
Perceived exertion	4.8±2.2 (3.1-6.5)	4.1±1.8 (2.7-5.5)	4.1±1.8 (2.7-5.5)	4.3±2.2 (2.6-6.0)	1.260	.308
Fast time (7)	62±6.2 (56.3-67.8)	63.3±13.8 (51.8-74.8)	60.4±13.3 (49.3-71.5)	61.1±14.6 (48.9-73.3)	3.449	.086
O_2-pulse (ml/beat)	11.3±2.5 (8.9-13.6)	12.9±4.6 (8.6-17.1)	12.8±2.9 (10.0-15.4)	12.7±4.2 (8.8-16.6)	1.199	.326
Perceived exertion	7.1±2.5 (4.8-9.5)	6.1±2.1 (4.4-7.9)	6.0±2.2 (4.2-7.8)	6.1±2.0 (4.4-7.8)	1.206	.334

Note: values are mean±SD (95% CI)

T1= baseline, T2=after one month of group meetings and individual practice, T3=after a further month of individual practice and limited telephone contact

T4= 2 months post-intervention and having returned pedometers to study centre, *significantly different from T1, *p*<.05, **significantly different from T1, *p*<.001, ***significantly different from T1, *p*<.01 † significantly different from T2, *p*<.05

Table 19: Perceived well-being repeated time points

Measure (*n*)	T1	T2	T3	T4	F	*p*
Vitality Plus Scale (9)	34.3±9.5 (27.1-41.6)	37.2±8.7 (30.6-43.9)	38.3±8.2 (32.0-44.63)	37.4±7.57 (31.63-43.3)	2.262	.130

Note: values are mean±SD (95% CI)

T1= baseline, T2=after one month of group meetings and individual practice, T3=after a further month of individual practice and limited telephone contact

T4= 2 months post-intervention and having returned pedometers to study centre.

Table 20: Dietary recall data at repeated time points (*n*=8)

Variable	Original Recommendations	T1	Between T2 and T3	Between T3 and T4	F	*p*
Total Kcal	1,489±264.9 (1,268.0-1,711.0)	1,627.6±421.6 (1,275.1-1,980.0)	1,748.8±895.9 (999.9-2,497.8)	1,843.5±766.6 (1,202.6-2,484.4)	0.177	.720
Protein (grams)	72.4±13.4 (61.1-83.6)	73.7±16.2 (60.1-87.2)	83.0±36.7 (52.4-113.6)	81.5±28.0 (58.1-104.9)	0.237	.748
Fat (grams)	55.8±12.6 (45.2-66.2)	55.0±19.2 (38.9-71.0)	79.5±52.3 (35.8-123.2)	74.2±60.3 (23.8-124.7)	0.629	.502
Carbohydrate (grams)	174.4±34.5 (145.6-203.3)	212.9±78.3 (147.4-278.4)	172.3±66.0 (117.0-227.5)	225.7±121.8 (123.9-327.6)	0.646	.492

Note: Note: values are mean±SD (95% CI). Original recommendations were obtained from patient charts

Figures

Figure 1: Pattern of change in average steps/day (mean, 95% CI)

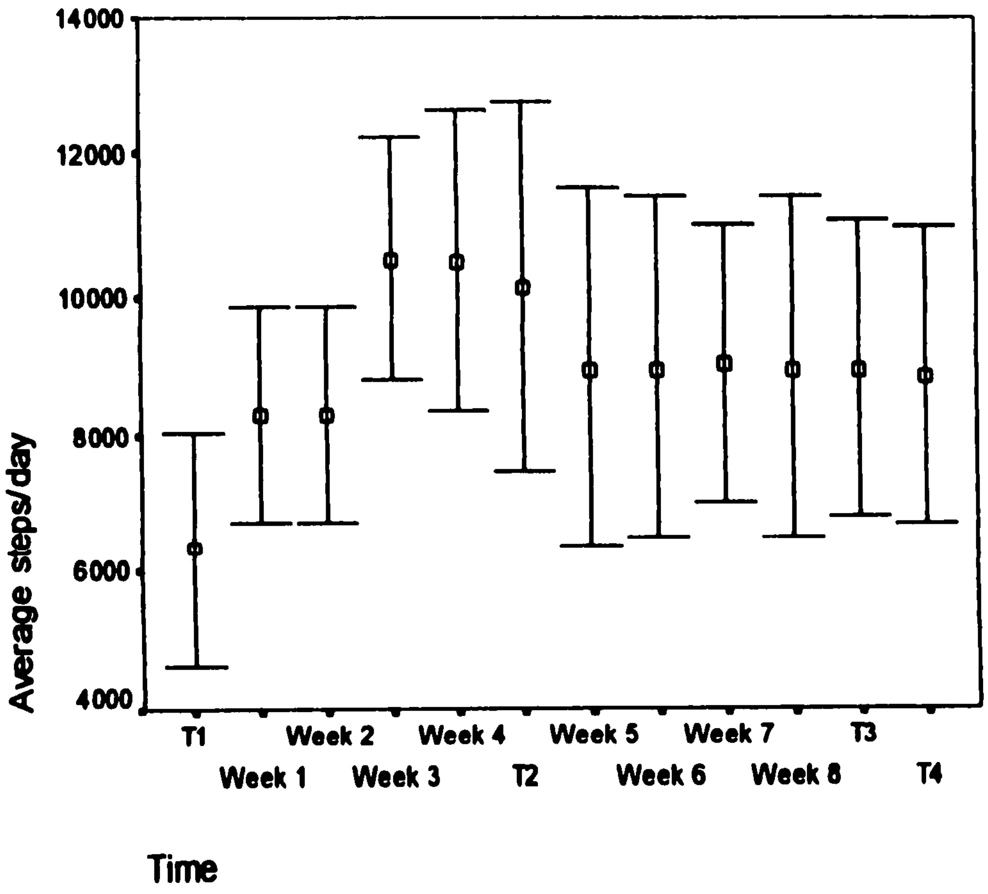


Figure 2: Importance of exercise to regular routine (mean, 95%CI)

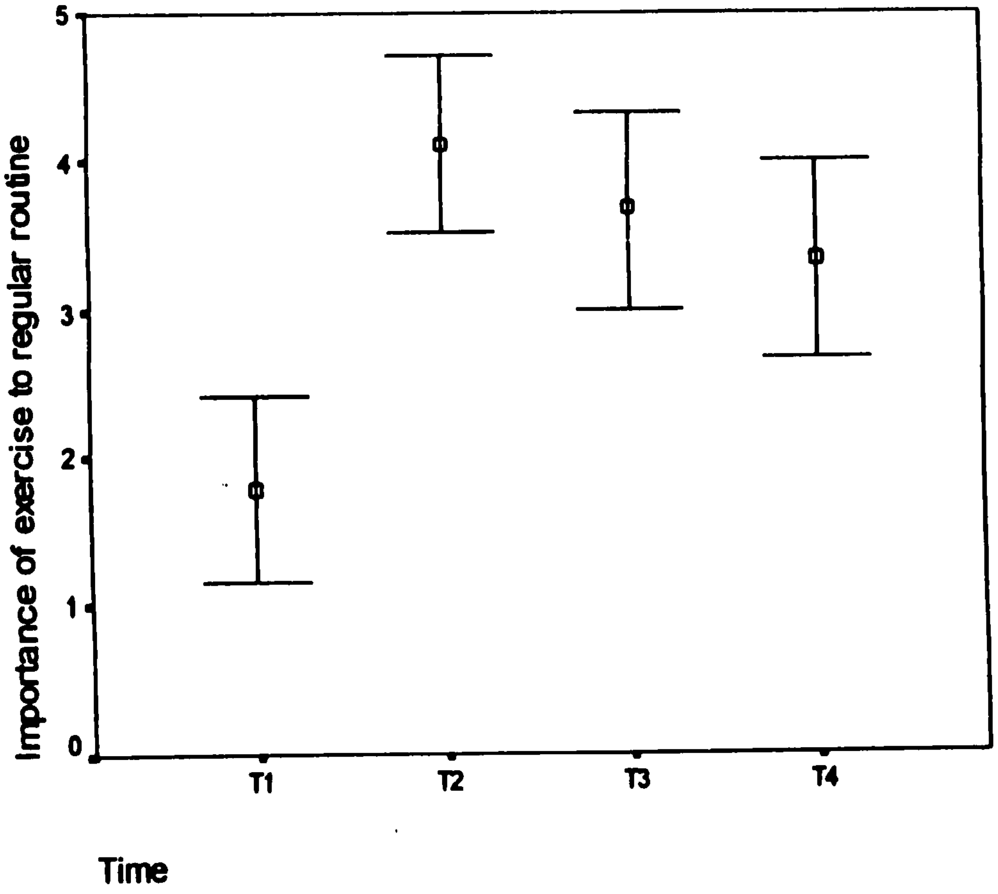


Figure 3: Increase in goal (steps per day) during first 4 weeks of program (mean, 95%CI)

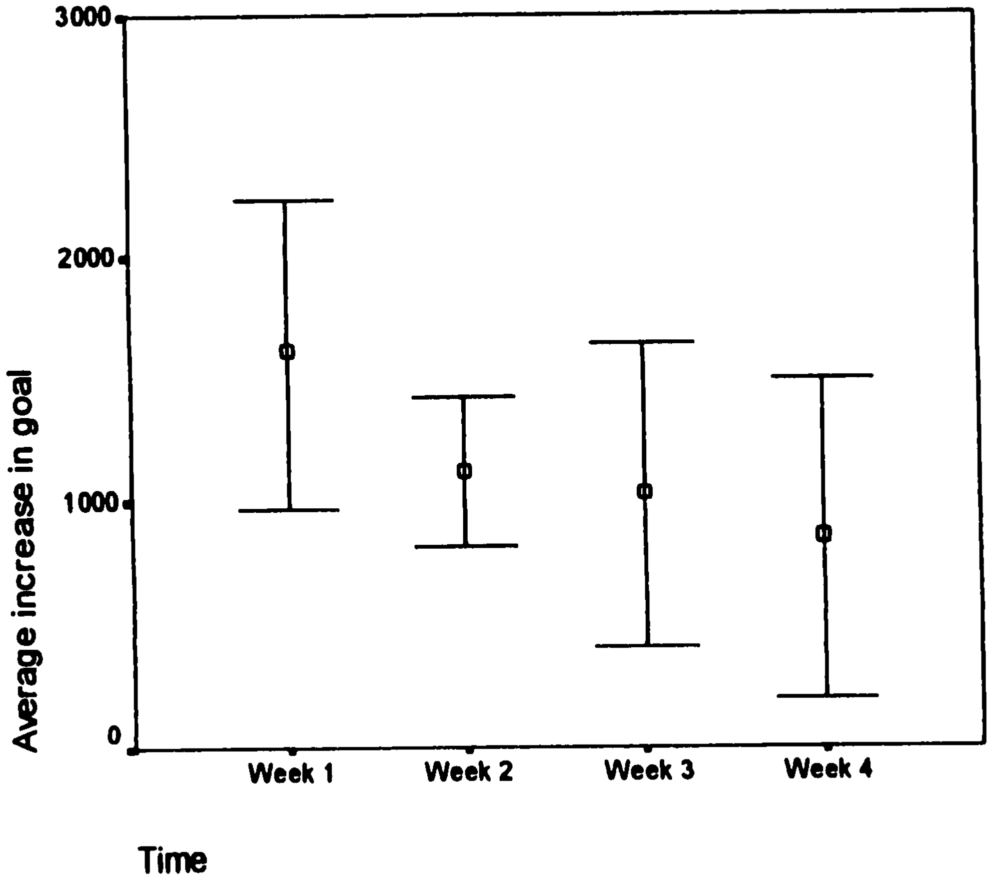


Figure 4: Goal attainment during 8 weeks of program (mean, 95%CI)

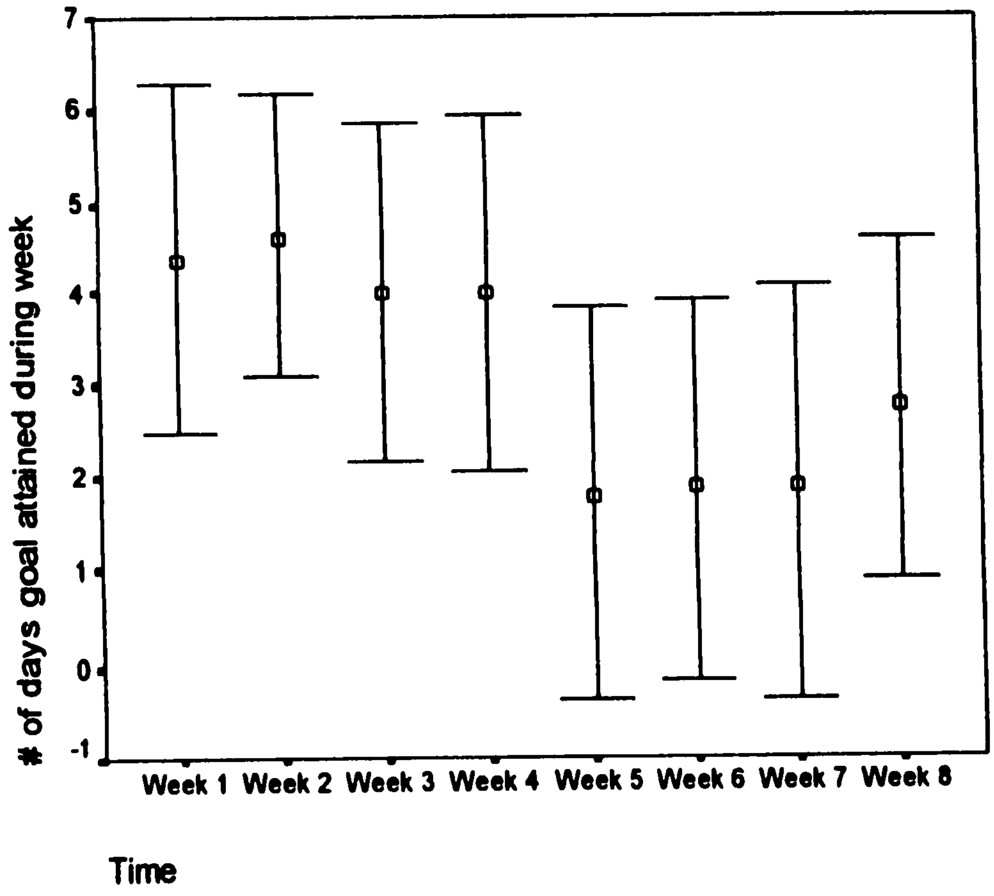


Figure 5: Confidence to "stick to it" over course of the study (mean, 95%CI)

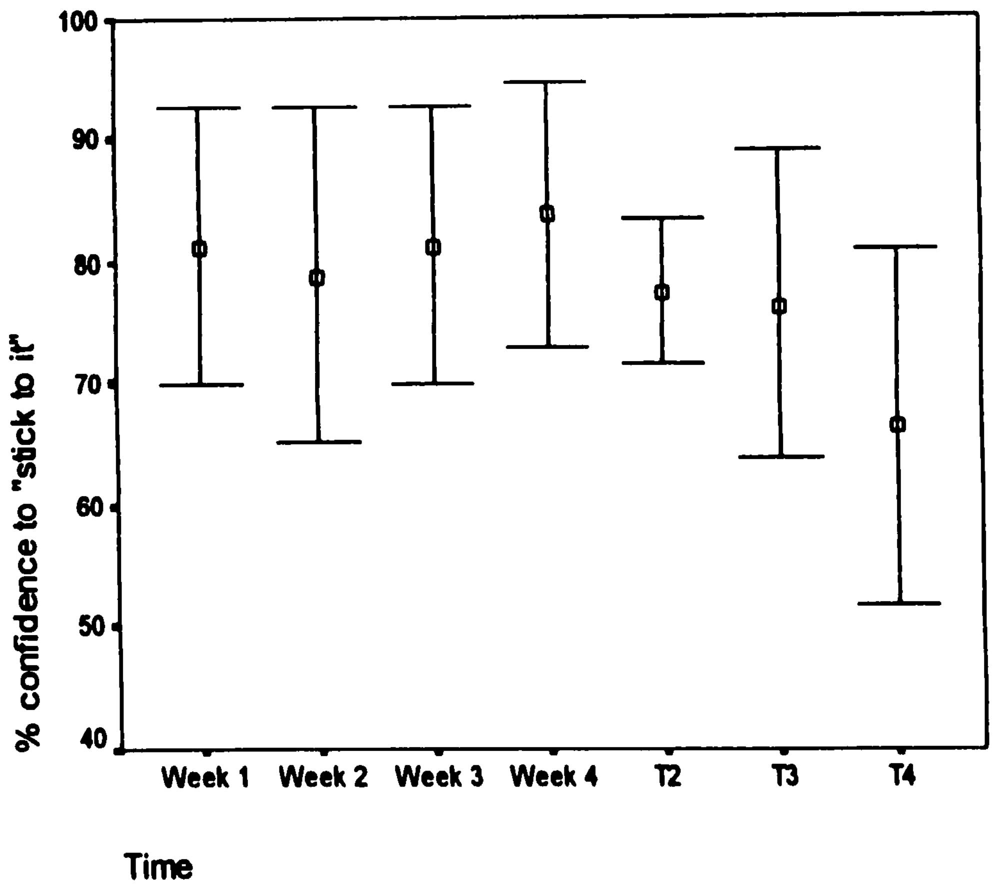
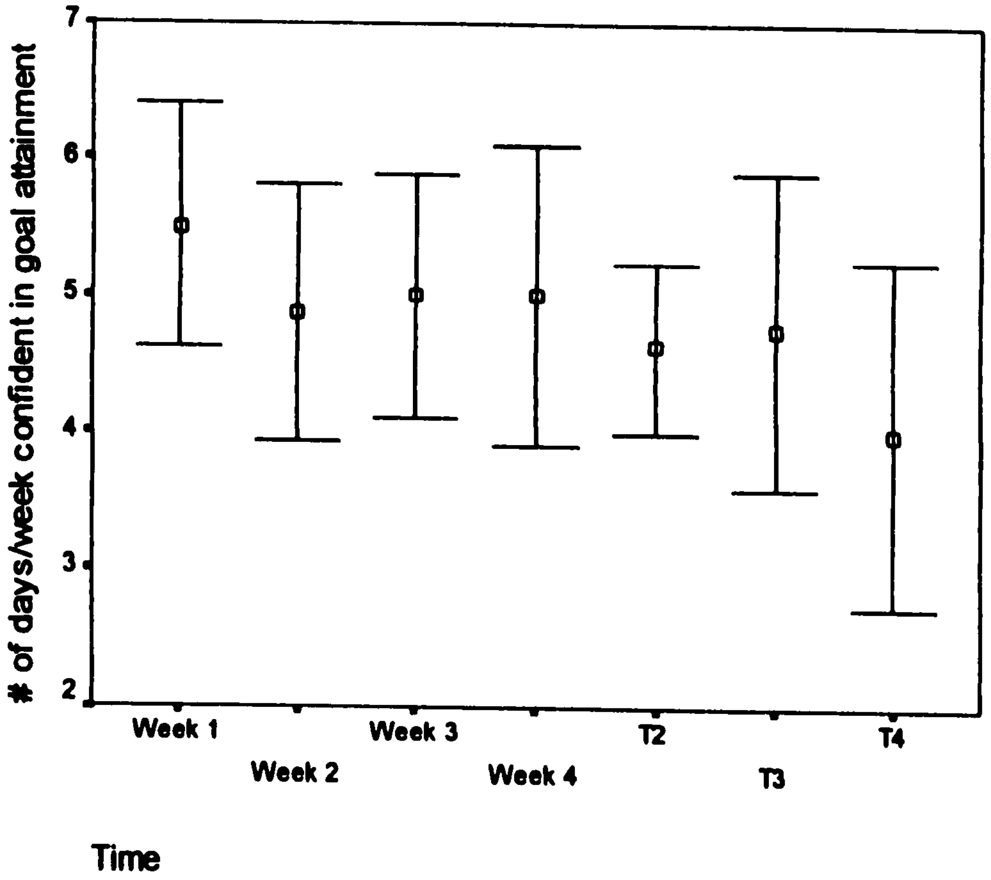


Figure 6: # of days/week confident in attaining goal (mean, 95%CI)



Appendices

Appendix A: Background questionnaire

1). Are you...____male? Or ____female?

2). What is your age? ______

3). What is the highest level of education you have reached?
- ____ some secondary/high school
- ____ high school diploma
- ____ some post-secondary
- ____ college or university diploma

4). In general, how would you describe your current state of health?
- ____ Excellent
- ____ Good
- ____ Fair
- ____ Poor

5). Are you a
- ____ Current smoker
  (if check, who wants to quit? ____ yes ____ no)
- ____ Occasional smoker
- ____ Never smoked
- ____ Former smoker (year stopped ___)

6). Would you describe yourself as...
- ____ Underweight
- ____ At the right weight
- ____ Overweight
  (if checked, are you a frequent dieter? ____ yes _____ no)

7). Have you been diagnosed by a health professional as having…(check all that apply)

Yes
____ Heart trouble
____ Chronic asthmas, emphysema, or bronchitis
____ Diabetes
____ Osteoporosis
____ Arthritis
____ High blood pressure
____ High cholesterol
____ Back problems
____ Foot problems
____ Allergies (including hay fever and sinus problems)
____ Trouble hearing
____ Trouble seeing
____ Bladder control difficulties
____ Other health problems (what are they?____________)

8). To what extent is exercising an important part of your regular routine?

1	2	3	4	5
Not at all		Moderately		Extremely
Important		Important		Important

9) Over a typical seven-day period (one week), how many times do you engage in physical activity that is sufficiently prolonged and intense to cause sweating and a rapid heart beat? (check one)

____ At least 3 times
____ Normally once or twice
____ Rarely or never

10). When you engage in physical activity, do you have the impression that you (check one):

____ Make an intense effort
____ Make a moderate effort
____ Make a light effort

11). In a general fashion, would you say that your current physical fitness is:

____ Very good
____ Good
____ Average
____ Poor
____ Very poor

Appendix B: Questions regarding outcome expectations imbedded in background questionnaire

1) In general, how confident are you that you can manage your diabetes?

0%	10	20	30	40	50	60	70	80	90	100%
Not at all Confident				Moderately Confident					Completely Confident	

2) How confident are you that being physically active will lower your blood glucose levels?

0%	10	20	30	40	50	60	70	80	90	100%
Not at all Confident				Moderately Confident					Completely Confident	

3) How confident are you that being physically active will lower your blood glucose levels?

0%	10	20	30	40	50	60	70	80	90	100%
Not at all Confident				Moderately Confident					Completely Confident	

4) How confident are you that being physically active will help prevent complications of diabetes?

0%	10	20	30	40	50	60	70	80	90	100%
Not at all Confident				Moderately Confident					Completely Confident	

Appendix C: Additional questions imbedded in background questionnaire at T2-T4

1) **In general, how many HOURS per DAY do you usually spend watching television?**
________ **hours**

2) **How confident are you that you can stick to your daily activity program?**

0%	10	20	30	40	50	60	70	80	90	100%
Not at all Confident				**Moderately** Confident					**Completely** **Confident**	

3) **How many days of the week are you confident that you will reach your daily activity goal over the next month?**

0 1 2 3 4 5 6 7

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