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## Review

## Vigorous Intensity Exercise for Glycemic Control in Patients with Type 1 Diabetes

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## ABSTRACT

Regular physical activity has substantial health benefits in persons with type 1 diabetes, including reduced risk of complications and cardiovascular mortality as well as improved self-rated quality of life. Despite these benefits, individuals with type 1 diabetes are often less active than their peers without diabetes. When factors such as time constraints, work pressure and environmental conditions are often cited as barriers to physical activity in the general population, 2 additional major factors may also explain the low rates of physical activity in young people with type 1 diabetes: (1) fear of hypoglycemia both during and after (particularly overnight) exercise and (2) a lack of empiric evidence for the efficacy of physical activity for achieving optimal glycemic control. A number of acute exercise trials recently showed that the inclusion of vigorous intensity physical activity in conventional moderate intensity (i.e. walking and light cycling) exercise sessions may overcome these barriers. No studies have tested the efficacy of high-intensity physical activity on glycemic control (A1C) or post-exercise hypoglycemia in a randomized controlled trial. This article summarizes the literature related to the role of physical activity for the management of blood glucose levels in individuals with type 1 diabetes and provides a rationale for the need of a randomized controlled trial examining the effects of vigorous-intensity physical activity on blood glucose control.

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## R É S U M É

L'activité physique régulière a des effets positifs substantiels sur la santé des personnes ayant le diabète de type 1, y compris la réduction du risque de complications et de mortalité liée à la maladie cardiovasculaire ainsi qu'une meilleure autoévaluation de la qualité de vie. En dépit de ces effets positifs, les individus ayant le diabète de type 1 sont souvent moins actifs que leurs pairs n'ayant pas le diabète. Lorsque des facteurs tels les contraintes de temps, la charge de travail et l'environnement souvent sont cités comme des obstacles à l'activité physique dans la population générale, 2 facteurs additionnels majeurs peuvent également expliquer les faibles taux d'activité physique chez les jeunes personnes ayant le diabète de type 1 : 1) la peur de l'hypoglycémie pendant et après (particulièrement la nuit) l'exercice; 2) le manque de données empiriques sur l'efficacité de l'activité physique pour atteindre une régulation glycémique optimale. Plusieurs essais sur l'exercice intense montraient récemment que l'introduction de l'activité physique d'intensité vigoureuse à des séances traditionnelles d'exercice d'intensité modérée (c.-à-d. la marche et le vélo de faible intensité) peut surmonter ces obstacles. Aucune étude n'a testé l'efficacité de l'activité physique d'intensité élevée sur la régulation de la glycémie (HbA1c) ou sur l'hypoglycémie après exercice lors d'un essai clinique aléatoire. Cet article résume la littérature en lien avec le rôle de l'activité physique sur la prise en charge des taux de glycémie chez les individus ayant le diabète de type 1 et justifie le besoin de réaliser un essai clinique aléatoire examinant les effets de l'activité physique d'intensité vigoureuse sur la régulation de la glycémie.

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## Introduction

Currently, more than 300 000 Canadians live with type 1 diabetes (1) and rates have increased globally over the past 2 decades (2). Type 1 diabetes is the most common endocrine condition in children and young adults (3). A diagnosis of type 1 diabetes increases the risk of microvascular and macrovascular complications, which can reduce life expectancy by up to 15 years (4). The increased morbidity and mortality associated with type 1 diabetes is reduced significantly with improved blood glucose (i.e. glycemic) control (5). The landmark Diabetes Control and Complications Trial and its prospective follow-up study (Epidemiology of Diabetes Interventions and Complications) clearly showed that targeting an A1C level of 7.0% reduces the risk of multiple complications, including retinopathy, neuropathy and nephropathy (6). The clinical approach to achieving this target generally relies on carefully titrated exogenous insulin and dietary control of carbohydrate intake. Increased physical activity is also often recommended for individuals with type 1 diabetes for the maintenance of overall health and the prevention of diabetes-related complications. There is strong evidence for the efficacy and optimal approaches for insulin and dietary management of A1C in individuals with type 1 diabetes (7,8). Unfortunately, the same evidence does not exist for physical activity.

Regular physical activity is associated with significant health benefits for patients with type 1 diabetes, including increased cardiorespiratory fitness, decreased insulin requirements, improved endothelial function, lower serum cholesterol, and increased vascular health along with improvements in body composition and quality of life (9). Collectively, these benefits are associated with a lower risk of complications and increased life expectancy for patients with type 1 diabetes (10). Despite these benefits, individuals with type 1 diabetes, similar to the general population in Canada, are predominantly inactive with more than 60% of adults with type 1 diabetes failing to achieve the recommended levels of physical activity for optimal health benefits (11). In addition to the commonly cited barriers to physical activity, such as lack of time, work pressure, environmental conditions and low energy, individuals with type 1 diabetes have additional challenges to contend with, such as: (1) a lack of consistent evidence for the appropriate dose (frequency, duration and intensity) of physical activity required for improving glycemic control, and (2) the fear of hypoglycemia both during exercise and subsequently overnight. Little qualitative research exploring physical activity in people with type 1 diabetes has been published. However, in the few qualitative

studies that have been conducted in youth (12) and adults (13) with type 1 diabetes, fear of hypoglycemia as a prevalent barrier or “transient disruptor” (12) to participation in physical activity has been confirmed.

## What is the Evidence That Physical Activity Can Reduce A1C Levels in Patients With Type 1 Diabetes?

Observational studies have shown that increased physical activity is associated with a lower A1C level among individuals with type 1 diabetes (14). In fact, cross-sectional studies identify regular time spent being physically active as one of the most important predictors of A1C level in persons with type 1 diabetes (14). Unfortunately, results from quasi-experimental and randomized controlled trials (Table 1) have yielded mixed results on the efficacy of physical activity in improving glycemic control (15–28). Some studies, particularly those of higher intensity and/or frequency of physical activity, show clinically meaningful 0.4% to 1.2% absolute reductions in A1C level in patients with type 1 diabetes whose blood glucose control at enrollment was fair to poor (A1C, 8.6%–15.1%) (15,16,19–21,23). In contrast, a significant proportion of quasi-experimental studies and some randomized controlled trials showed little effect of physical activity on A1C level (17,18,22,25–27,29). The disparity in trial results can be attributed to heterogeneity of participants at study entry (age, A1C level and duration of diabetes), heterogeneity in the intervention dose (i.e. duration, frequency and intensity of physical activity) and a lack of study power (Table 2). Also, the majority of studies were published before the introduction of the Consolidated Standards of Reporting Trials (CONSORT) guidelines for reporting randomized controlled trials and, therefore, suffer from major design flaws.

A series of descriptive and systematic reviews of physical activity for metabolic control in individuals with type 1 diabetes have been published recently (9,30,31). Reviews that included a meta-analysis of randomized controlled trials showed that the improvements in glycemic control with exercise training in individuals with type 1 diabetes are quite heterogeneous. The variability in the response to training can be explained by several factors including the age of participants at randomization, the lack of adequately powered trials, heterogeneous inclusion criteria and varying doses of physical activity delivered. For example, youth (aged <18 years) appear to achieve greater absolute reductions in A1C level (–0.37%; 95% confidence interval [CI] –0.77% to 0.02%) with physical activity than adults (0.00%; 95% CI –0.55% to 0.50%), whereas interventions lasting longer than 3 months (–0.75%; 95%

**Table 1**  
Summary of randomized controlled trials of aerobic exercise in individuals with type 1 diabetes

Study	Age (years)	N (treatment/ control)	Time (minutes)	Frequency (per week)	Intensity % HR max	Duration (weeks)	A1C Δ control (%)	A1C Δ treatment (%)
Yki-Jarvinen et al (29)	24–27	6/7	60	4	70% V <sub>02</sub> max	6	0.8	0.3
Campaigne et al (21)	5–11	10/9	30	3	72% HR max	12	–0.6	–1.2*
Landt et al (27)	14–16	6/9	45	3	80%–85% HR max	12	0	0
Wallberg-Henriksson et al (26)	25–45	7/6	20	7	60–90% V <sub>02</sub> max	20	–0.2	0.1
Huttunen et al (25)	8–17	16/16	60	1	68% HR max	12	0.3	0.7
Laaksonen et al (24)	20–40	28/28	30–60	3–5	50%–60% V <sub>02</sub> max	12–16	0.2	–0.2
Salem et al (20)	12–18	48/73	60	3	65%–95% HR max	24	0.6	–1.1*
Tunar et al (28)	12–17	14/17	45	3	N/A	12	–0.5	–0.1
Average	15–24	17/21	45.6	3.5	~75% HR max	14	0.08	–0.19

HR max, maximum heart rate; V<sub>02</sub>, maximum oxygen consumption.

\* Significant change in A1C level (p<0.05).

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