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## Review

## Effects of High-Intensity Interval Training on People Living with Type 2 Diabetes: A Narrative Review

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## ABSTRACT

People with type 2 diabetes typically present with comorbidities, such as elevated blood pressure, high cholesterol, high blood glucose, obesity and decreased fitness, all contributive to increased risk for cardiovascular complications. Determination of effective exercise modalities for the management of such complications is important. One such modality is high-intensity interval training (HIIT). To conduct the review, PubMed and EBSCOHost databases were searched through June 1, 2016, for all HIIT intervention studies conducted in people living with type 2 diabetes. Thereafter, the central characteristics of HIIT were analyzed to obtain a broader understanding of the cardiometabolic benefits achievable by HIIT. Fourteen studies were included for review, but the heterogeneity of the participants with type 2 diabetes, the training equipment and HIIT parameters, accompanied by variations in supervision, dietary advice and medications, prevented direct comparisons. However HIIT, regardless of the specific parameters employed, was a suitable option in pursuing improved glycemic control, body composition, aerobic fitness, blood pressure and lipidemia measures in individuals with type 2 diabetes. HIIT is a therapy with at least equivalent benefit to moderate-intensity continuous training; hence, HIIT should be considered when prescribing exercise interventions for people living with type 2 diabetes.

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## R É S U M É

Les personnes souffrant du diabète de type 2 présentent habituellement des comorbidités telles qu'une pression artérielle élevée, un cholestérol élevé, une glycémie élevée, une obésité et une moins bonne forme physique, qui toutes contribuent à l'augmentation du risque de complications cardiovasculaires. La détermination de modalités d'entraînement efficaces pour prendre en charge ces complications est importante. L'une de ces modalités est l'entraînement par intervalles à haute intensité (EIHI). Pour réaliser la revue, nous avons consulté les banques de données PubMed et EBSCOHost jusqu'au 1er juin 2016 afin de trouver toutes les expérimentations menées auprès des personnes vivant avec le diabète de type 2 sur l'EIHI. Par la suite, nous avons analysé les caractéristiques principales de l'EIHI pour mieux comprendre les avantages cardiométaboliques que l'EIHI peut permettre d'atteindre. Bien que la revue ait englobé 14 études, l'hétérogénéité des participants souffrant du diabète de type 2, le matériel d'entraînement et les paramètres de l'EIHI associés à des variations dans la supervision, les conseils en matière d'alimentation et les médicaments empêchaient de faire des comparaisons directes. Toutefois, l'EIHI, indépendamment des paramètres précis employés, était une option appropriée dans la poursuite de l'amélioration de la régulation glycémique, de la constitution corporelle, de l'aptitude physique aérobie, des mesures de la pression artérielle et de la lipidémie chez les individus souffrant du diabète de type 2. L'EIHI est une thérapie qui est au moins aussi avantageuse que l'entraînement continu d'intensité modérée. En conséquence, l'EIHI devrait être considérée lors de la prescription de programmes d'exercices aux personnes vivant avec le diabète de type 2.

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## Introduction

Type 2 diabetes mellitus is 1 of the largest global health epidemics of the 21st century (1). Those afflicted typically present with comorbidities, such as hypertension, dyslipidemia and other risk factors (e.g. abdominal obesity and decreased aerobic fitness), all contributive to increased risk for cardiovascular complications (2,3). Established type 2 diabetes management strives, via medication optimization and lifestyle changes (4), to reduce these risk factors but has, to date, demonstrated varied success in improving glycemic control (GC) and preventing diabetic complications. Two large-scale, long-term follow-up studies in people living with type 2 diabetes (5,6), in which all participants received education and lifestyle advice along with antihyperglycemic medication either to maintain their GC targets of achieving glycated hemoglobin (A1C) levels of around 53.0 mmol/mol or to intensify GC, achieving A1C levels below 48.0 mmol/mol, found that although there were positive effects on microvascular complications, long-term intensive GC did not lead to further long-term benefits with respect to mortality or macrovascular events. Wing et al (7), reporting on the Look AHEAD project, in which participants accumulated 175 minutes of moderate-intensity physical activity each week, coupled with a calorie-restricted diet, for 1 year, concluded that intensive lifestyle interventions focused on weight loss, counselling and increased, unsupervised, moderate-intensity physical activity did not reduce the cardiovascular events in adults with type 2 diabetes. As is evident in these investigations, the optimum GC strategy for the treatment of type 2 diabetes and its macrovascular complications is unclear and, therefore, further investigations into alternative strategies that focus on the comprehensive reduction of cardiometabolic risks, for example, structured exercise interventions and/or low-carbohydrate dietary approaches, are warranted.

The lifestyle factors of diet and physical activity are central to the management of type 2 diabetes because they both help to treat the associated lipid, blood pressure (BP), body weight and blood glucose control abnormalities (8), and it is recommended that when medications are used to control type 2 diabetes, they should augment lifestyle improvements, not replace them (8). Notwithstanding the influence of diet on type 2 diabetes, this review focuses on exercise interventions. Structured exercise modalities have been promoted by several authors as a vital component to manage type 2 diabetes (9–17). One such exercise modality is high-intensity interval training (HIIT), and although it has recently attracted much attention (18–26), the potential for prescribing HIIT for type 2 diabetes has not been fully investigated. Limited reviews of the effects of HIIT interventions have been conducted in type 2 diabetes (27,28) as well as in clinical conditions related to type 2 diabetes, such as lifestyle-induced cardiometabolic disease (29), vascular function (30), glucose regulation and insulin resistance (13,31) and, most recently, common metabolic diseases (32). Moreover, the paucity of randomized controlled trials (RCTs) involving HIIT interventions on type 2 diabetes is evident; only 6 such studies to date have been included for analysis across all 6 of these reviews. Hence, the rationale of this review was to look beyond RCTs and to conduct a review including all HIIT interventions reported for adults with type 2 diabetes, with the purpose being 3-fold: 1) the effects of HIIT on GC measures; 2) the effects of HIIT on cardiometabolic risk factors and 3) the summarization of the central characteristics of HIIT.

## Methods

### Literature search

PubMed and EBSCOhost databases were searched with no date restrictions (until June 1, 2016) for HIIT intervention studies

conducted in people with type 2 diabetes. There is no universal definition of HIIT (29), so the following principle was applied to the search: intermittent bouts of vigorous (or higher intensity) exercise of up to 4 minutes per bout, interspersed with recovery periods of lower intensity exercise (or complete rest). Terminology frequently used to describe HIIT were searched in titles and abstracts using the following search terms: high-intensity, HIIT, interval training, sprint interval, Wingate in combination with (using the Boolean AND command) diabetes, type 2, glucose, glycemic control and glycemic control. Titles and abstracts of returned articles were evaluated (and when further clarity was needed, the full text was perused) so as to include only intervention studies of human participants with type 2 diabetes. Additionally, the reference lists from the retrieved articles and reviews were manually checked to search for further relevant articles. Full-text publications of controlled and uncontrolled HIIT intervention studies were included for review. Acute-response studies and studies not published in English were excluded. The entire literature search was conducted independently, with no blinding to study authors, institutions or manuscript journals.

The number of studies investigating HIIT in type 2 diabetes was limited and was compounded by considerable differences in HIIT application and use of comparison groups (if at all), so we chose to avoid systematically rating the quality of the research but, rather, to use a narrative review for a nuanced approach to our critique. The differences in the participants with type 2 diabetes, the study designs and the HIIT parameters utilized across the various studies are discussed throughout this review. Table 1 presents the study duration, participants' characteristics, type 2 diabetes status, adherence rates and specific intervention protocol parameters used. For the purpose of this review, short- and medium-term interventions were defined as 1 to 4 weeks and more than 4 to 26 weeks, respectively. Additionally, HIIT interventions that utilized high-intensity bouts of 60 seconds or longer and those 30 seconds or less are referred to as aerobic interval training (AIT) or sprint interval training (SIT), respectively.

### Study participant and intervention variables

After the full-text analysis of the retrieved articles, 14 studies involving adults with type 2 diabetes were included for review. The studies, published between 2008 and 2016, involved 279 study participants (SPs). As with all research in human participants, the SPs were volunteers who provided informed consent, thereby possibly constituting a positive attitude toward exercise and/or research as well as possibly being internally motivated to make changes to their lifestyles (33). The mean number of SPs with type 2 diabetes across the intervention and comparison groups was  $11.3 \pm 3.4$  and  $11.0 \pm 3.2$ , respectively.

Although the low numbers of SPs confound the ability to determine statistical significance within and between groups, they are possibly indicative of the low numbers of participants with type 2 diabetes who volunteer for exercise interventions (33), the logistics of supervised HIIT interventions (34) and/or the comorbidities associated with type 2 diabetes that exclude many volunteers (34,36,37). The studies reported drop-outs (in limited cases, 1 to 2 per group, and they were comparable among intervention groups) for various reasons, including minor medical reasons (discussed under Adverse Effects) and nonmedical reasons (transport, work commitments) (36–42).

The general SP exclusion criteria were similar for all studies (unless stated) and included severe retinopathy, severe cardiovascular disease, impaired liver function, macroalbuminuria, severe asthma, cancer, musculoskeletal injuries or any other contraindications to exercise. Seven studies excluded participants using exogenous insulin (34,35, 37, 8,40,43,44). Additionally, participants underwent a screening process, and those with

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