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Review

Exercise as Medicine: Key Concepts in Discussing Physical Activity with Patients who have Type 2 Diabetes

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ABSTRACT

People with type 2 diabetes stand to benefit substantially from being physically active. Practice guidelines consistently recommend that people with diabetes obtain at least 150 minutes of moderate to vigorous aerobic exercise per week. Although the message of 150 minutes per week is important, there are several other key messages regarding physical activity that may not be communicated as often or as clearly. This article gives an overview of the importance of resistance training, the dose-response relationship between physical activity and health outcomes, and the emerging evidence concerning the role of sedentary behaviour in people with type 2 diabetes. This article provides valuable content for healthcare providers that will help to inform their discussions about physical activity with patients who have type 2 diabetes.

RÉSUMÉ

Les personnes souffrant du diabète de type 2 profitent grandement de l'activité physique. Les lignes directrices de pratique recommandent invariablement que les personnes diabétiques cumulent chaque semaine au moins 150 minutes d'exercice aérobique d'intensité modérée à vigoureuse. Bien que le message des 150 minutes par semaine soit important, il existe plusieurs autres messages essentiels au sujet de l'activité physique qui ne sont pas communiqués aussi souvent ou aussi clairement. Cet article donne un aperçu de l'importance de l'entraînement musculaire, de la relation dose/effet entre l'activité physique et les preuves émergentes sur le rôle du comportement sédentaire chez les personnes souffrant du diabète de type 2. Cet article offre un contenu précieux aux prestataires de soins de santé qui aidera à alimenter leurs discussions sur l'activité physique avec les patients atteints du diabète de type 2.

Introduction

Physical activity is a key component in the management of type 2 diabetes. Extensive evidence has established that participation in regular exercise by people with type 2 diabetes improves blood glucose control, reduces diabetes complications and has favourable effects on cardiovascular events, mortality and quality of life (1-4). Consequently, being physically unfit carries an excess risk for mortality similar to that of cigarette smoking (5,6). Current Canadian Diabetes Association clinical practice guidelines (4) recommend that all patients with diabetes obtain at least 150 minutes of moderate to vigorous aerobic exercise per week, and this recommendation is in agreement with guidelines from numerous organizations (1,7-9). Accordingly, substantial public-health messaging efforts have been applied to promote the uptake of this guideline (10,11). Although the message of 150 minutes per week of moderate to vigorous aerobic exercise is important, there are several other key messages regarding physical activity that may not be communicated as often or as clearly. Messages regarding the importance of resistance training (strength training), the dose-response relationship between physical activity and health outcomes, and the harms of sedentary behaviour are sometimes diminished or even overlooked. This article aims to provide an overview of the current evidence associated with these important aspects of physical activity in the hope of providing useful content for discussions about exercise with patients who have type 2 diabetes.

In this article, we use the term *exercise*, which is defined as *planned, structured physical activity done with the intention of increasing physical fitness (i.e., cardiovascular and/or resistance training)* (12). However, please note that in the literature, the broader term *physical*

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activity, which is defined as *bodily movement produced by the contraction of skeletal muscle that substantially increases energy expenditure* (12), is sometimes used interchangeably. Although we chose to use the term *exercise*, our intent is to recognize that many types of physical movement may have positive effects on physical fitness, morbidity and mortality in individuals with diabetes.

The Value Added by Resistance Training: Strength of the Evidence

Muscular strength, defined as the ability of a muscle to exert force (12), is an integral component of physical functioning, and increasing muscular strength is the goal of resistance training. Although clinical practice guidelines (1,4,8,9) recommend that adults with diabetes perform resistance training at least 2 to 3 days per week, resistance training has tended to receive much less attention than aerobic training. Although many adults with type 2 diabetes are failing to meet the minimum recommended levels of aerobic exercise, even fewer are meeting the recommendations for resistance training exercise. In one population-based survey, 55% of people with diabetes reported engaging in walking for exercise, while only 12% reported engaging in resistance training (13). A more recent study (14) reported that only 2.5% of patients with diabetes in Atlantic Canada reported meeting both the aerobic and resistance training guidelines. This discrepancy is unfavourable because strength, in and of itself, is a clinically important health outcome, and many important health benefits are to be gained by performing resistance training.

In sedentary adults, muscle mass and strength decrease progressively with age, particularly after age 45, with a more rapid reduction after age 60 (15,16). Diabetes is an independent risk factor for low muscular strength (17), and older patients with type 2 diabetes have accelerated declines in muscle mass and strength when compared with age-matched nondiabetic controls (18-20). This age-related loss of muscle mass can be concurrent with increased physical impairment and decreased ability to perform functional tasks, such as climbing stairs, standing up from a chair and doing basic household chores, all tasks that require a threshold of muscular strength. Low muscular strength is associated with higher disability, morbidity and mortality (21). In a large long-term cohort study, men in the lowest tertile of muscular strength for their age group had 23% greater all-cause mortality (22), 32% greater cancer mortality (22,23) and 29% greater cardiovascular disease mortality (22) compared to men in the middle and highest strength tertiles.

Resistance training includes exercises performed using weights, weight machines, resistance bands, or one's own body weight as resistance (e.g. pushups and squats). Resistance training can delay, prevent and, in some cases, reverse the effects of sarcopenia (24,25). Furthermore, resistance training can promote the maintenance of muscular strength and enhance mobility and functional independence further into old age (26,27). Beyond increasing lean muscle mass, another key role of resistance training is to prevent or limit the loss of lean body mass in individuals who are reducing food intake to reduce body weight (28); and resistance training appears to be more effective than aerobic-only training programs. Furthermore, resistance training can significantly improve bone mineral density (29,30), potentially preventing the deleterious effects of osteoporosis.

For people with type 2 diabetes, regular resistance training appears to be particularly beneficial because it can improve insulin action (31) and glycemic control (2). In a meta-analysis, Umpierre and colleagues (2) reported 0.57% reduction in glycated hemoglobin (A1C) levels in studies in which resistance training alone was compared with a nonexercise control in people with type 2 diabetes. The main tissues in the body that are sensitive to insulin are muscles and adipose cells. By increasing the quantity and insulin sensitivity of skeletal muscle through resistance exercise, most individuals can better manage blood glucose levels and body weight (26). Resistance training is thought to improve glycemic control and insulin sensitivity through a number of training adaptations. These include mechanisms such as increased levels, translocation and density of glucose transporter 4 (GLUT4) receptors; increased insulin receptor protein expression, resulting in an insulin-sensitizing effect of training; increased protein kinase B content, resulting in increased insulin action; and increased glycogen synthase concentration and glycogen synthase total activity, both of which mediate improved glucose clearance in trained muscles following acute training (32,33). For a more thorough review of the mechanisms postulated to combat metabolic dysfunction through resistance training in patients with type 2 diabetes, see the article by Strasser and Pesta (33).

Although the benefits of resistance training are considerable, it appears that a combination of *both* aerobic and resistance exercise may provide people with type 2 diabetes with the greatest yield on investment. The effect of combined training in people with type 2 diabetes has been demonstrated in several large trials (28,34,35). In the Diabetes Aerobic and Resistance Exercise (DARE) trial (34), 251 sedentary adults with type 2 diabetes were randomized to aerobic training, resistance training, combined training or waiting-list control. Absolute A1C changes compared to control were –0.51% in the aerobics-only training group, –0.38% in the resistance training-only group, and –0.97% in the combined aerobic and resistance training group. Resistance training, either alone or in combination with aerobic exercise training, reduced levels of atherogenic remnant-like particles (36) and also significantly improved vitality and the mental health dimensions of quality of life compared to either aerobic exercise alone or nonexercise controls (37). In the Health benefits of Aerobic and Resistance Training in type 2 Diabetes (HART-D) trial (28), 262 patients with type 2 diabetes were randomized to 3 times weekly aerobic training, resistance training, both types of training or control. Unlike the DARE trial, the combined group performed smaller amounts of aerobic and resistance exercise, so total weekly exercise time was about the same among the 3 groups, and no efforts were made to minimize dietary or medication co-intervention. The absolute reduction in A1C levels in the HART-D study was statistically significant compared to control only in the combined training group (–0.34%). In addition to the greatest A1C level reductions, the combined group also had a greater proportion of participants with decreases in hypoglycemic medication, even if total exercise time was held constant.

Further evidence for the benefits of combined training comes from the Italian Diabetes and Exercise Study (IDES) (35), in which 606 patients with type 2 diabetes from 22 centres (aged 40 to 75 years, mean A1C levels 7.13%) were randomized to either an intervention group that performed aerobic and resistance training in exercise facilities under the supervision of personal trainers twice weekly or a control group of exercise counselling alone. Compared to the control group, the group receiving facility-based training had significantly better results in essentially all outcomes, including A1C levels (intergroup difference of –0.30), aerobic fitness, strength, blood pressure, lipids, waist circumference, markers of systemic inflammation and estimated 10-year cardiovascular risk. With more than 600 subjects, IDES was larger than previous exercise trials in people with type 2 diabetes, allowing greater statistical power to detect small but clinically significant changes in a variety of important outcomes.

To date, the majority of published studies have carried out resistance exercise using weight machines and/or free weights. In real-world practice, training with elastic resistance bands is attractive because of much lower costs, easier access and minimal equipment needs. Although the use of resistance bands is appealing, their efficacy in the diabetes population is still unclear. In a recent