BRIEF REVIEW THE ROLE OF HIGH-INTENSITY INTERVAL TRAINING IN THE BATTLE AGAINST TYPE II DIABETES

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ABSTRACT

Despite the widely publicized and well-accepted benefits of regular exercise for improving metabolic health, adherence to the current exercise guidelines for the management of type 2 diabetes remains, to the disappointment of fitness professionals, surprising low. High-intensity interval training has sufficient data to allow trainers and clinicians to prescribe this low-volume, time saving exercise modality to improve glucose control over the 24-hour period after the exercise session. This is of practical importance for two reasons, (1) achieving marked improvements in 24-hr glucose regulation is a primary therapeutic goal to manage T2DM and (2) the benefits seen with such a small time investment may increase the likelihood of longer-term compliance to the exercise program leading to improved health outcomes.

Keywords: Insulin resistance, glucose control, type II diabetes, exercise training, high-intensity interval training

Introduction

Exercise is a well-accepted therapy for the management and the reduction of risk for many chronic diseases (Blair et al. 2012). Traditionally, the most common exercise prescription emphasizes continuous moderate-intensity aerobic exercise. Current exercise guidelines recommend ≥30 minutes per day of moderate-intensity activity (≥150 minutes per week) and/or vigorous-intensity exercise training for ≥20 minutes per day on ≥3 days of the week (≥75 minutes per week) (Garber et al. 2011). This prescription agrees with the current American College of Sports Medicine/American Diabetes Association (ACSM/ADA) exercise guidelines for the prevention and treatment of type 2 diabetes (T2DM) (Colberg et al. 2010). A recent position stand issued from Exercise & Sports Science Australia recommends an even higher time commitment suggested by the ACSM/ADA of a minimum of 210 min per week of moderate-intensity exercise or 125 min per week of vigorous intensity exercise (Hordern et al. 2012).

However, it has been long appreciated by clinicians and fitness professionals, that, despite the knowledge that regular exercise benefits health and diabetic outcomes, convincing at risk patients to accumulate 150 minutes a week of exercise has proven challenging, with many not acquiring sufficient weekly exercise to gain benefit (Trost et al. 2002; Trojano et al. 2008), with the most commonly cited barrier to exercise being 'lack of time' (Godin et al. 1994) or traditional continuous endurance-type training considered to be 'boring' as the reasons for not engaging in regular physical activity (Bartlett et al. 2011).

The last decade has seen a series of studies published that has explored the potential of low volume, high-intensity interval training (HIT) to be an effective exercise therapy to improve health, inducing similar central and peripheral adaptation to those seen from traditional continuous exercise (Gibala et al. 2006). HIT has been demonstrated to be a potent, time-saving training method, potentially overcoming the resistance to regular exercise, due to the minimal time commitment and the perceived enjoyable nature of the intermittent exercise (Barlett et al. 2011). For an excellent review of the role of HIT in health and performance, see Gibala et al. (2012).

Hit And Health

Modern studies have demonstrated the effectiveness of HIT to exert an adaptational response of similar or even greater magnitude than moderate-intensity continuous exercise training for improving endothelial function and reversing left ventricular remodelling in patients with heart failure (Wisløff et al. 2007), for improving vagal tone and decreasing arrhythmias (Guiraud et al. 2013), for reducing central body fat and fasting plasma insulin in young women (Trapp et al. 2008), for lowering post prandial triglyceride levels in health men (Trombold et al 2013), for increasing brachial artery flow-mediated dilation and cardiorespiratory fitness in patients with coronary artery disease (Currie et al 2013) and for improving maximal oxygen uptake (VO2max) in subjects with metabolic syndrome (Tjønna et al., 2008), heart failure (Wisløff et al. 2007), and coronary artery disease (Rognmo et al. 2004).

Glycemic Stability

The best predictors of increased diabetes risk and progression to T2DM are hyperglycaemia, abnormal glucose tolerance and impaired insulin-stimulated glucose uptake (American Diabetes Association, 2004; Hawley & Lessard 2008). The importance of elevated basal glucose levels and HbA1C as a CVD risk factor is well established, with HbA1C directly associated with increased CVD risk and all-cause mortality (Stratton et al. 2000). Current WHO criteria for diagnosis of T2DM are based solely on the results of epidemiological studies that have determined the risk of developing retinopathy over a range of plasma glucose levels (WHO/IDF, 2006). These diagnostic cut-off points provide only a 'snapshot' of glycaemic status at any time-point and impart no information on ambulatory postprandial and/or nocturnal glucose excursions, the so-called 'hyperglycemic spikes' that are an early and often undetected feature of the insulin resistant state (Hay et al. 2003; van Dijk et al. 2011). Indeed, these 'hyperglycaemic spikes' are more predictive for the onset of CVD complications than elevated fasting plasma glucose (Ceriello 2003; 2005; Ceriello & Colagiuri 2008) and are strongly associated with HbA1c content in both individuals with pre-diabetic and patients with T2DM (Praet et al. 2006). Recent technological innovations in Continuous Glucose Monitoring Systems (CGMS) have enabled comprehensive (up to six days) glucose profiling measurements to be incorporated in research studies (Maran et al. 2008). Such measurements are essential to assess the efficacy of any therapeutic intervention on an individual level, thereby achieving the goal of optimal metabolic control.

The most robust study to date which has utlized CGMS to evaluate the effect of various exercise modes on glycemic control was performed recently by van Dijk et al. (2012), who examined the acute effects of resistance compared with continuos aerobic exercise in three states of glyceamic impairment (impaired glucose tolerance, T2DM on oral glucose lower medication and T2DM on insulin) with 15 middle-aged overweight to obese males in each group. This study demonstrated a 7-12% reduction in 24-hr glucose concentrations after exercise, with no significant differences between exercise modes (Figure 1).

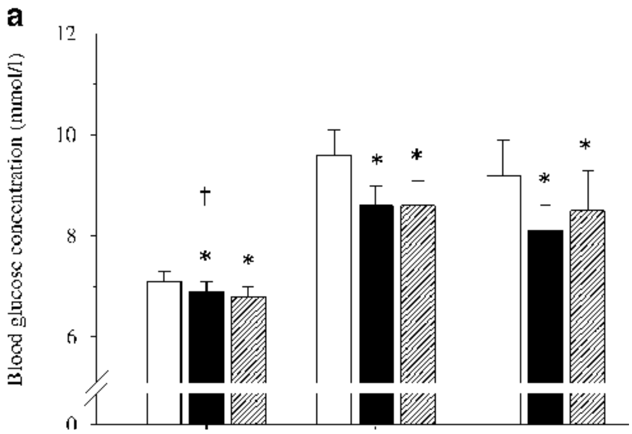

Figure 1. Average glucose concentrations (a) in individuals with IGT, type 2 diabetic patients using OGLM only, and type 2 diabetic patients using insulin, assessed over the 24 h following no exercise (control; white bars), resistance-type exercise (black bars) and endurance-type exercise (hatched bars). Significantly different compared with the control experiment (*p < 0.05); significant group effect compared with OGLM and INS groups (†p<0.05). Data from van Dijk, et al. 2012. Both resistance and endurance-type exercise reduce the prevalence of hyperglycaemia in individuals with impaired glucose tolerance and in insulin-treated and non-insulin treated type 2 diabetic patients. Diabetologia. 55: 1273-1282.

Modern Studies On Hit On Glucose Control

Several studies have investigated the effect of HIT on glucose tolerance in healthy individuals (Babraj et al 2009; Burgomaster et al. 2007; Nybo et al 2010; Richards et al 2010; Whyte et al. 1020; 2012; Sandveil et al. 2012) or on insulin resistance or T2DM (Kjaer et al. 1990; Earnest et al 2013). Only two studies to date report the effects of HIT on 24-hour glycaemic stability using CGMS in patients with T2DM (Little et al. 2011; Gillen et al. 2012). The available emerging evidence suggests that HIT is a potent, time-efficient and well-tolerated therapeutic intervention to increase cardiorespiratory fitness and improve glycaemic control in patients with or without T2DM (Bird & Hawley 2012; Adams 2013).

Hit And 24-Hr Glucose Stability

Little et al. (2011) examined the effects of six sessions of HIT (10 x 60-s cycling bouts eliciting ~90% maximal heart rate, interspersed with 60-s rest) in 8 individuals with T2DM over two weeks using CGMS 48-72 hours after the last training session. The frequency of the exercise regime was 3 times a week (Mon, Wed, Fri) for 2 consecutive weeks. This study found that for 48-72 hours following the final session of a 2 week low-volume HIT protocol under standard dietary conditions, the average 24-hour blood glucose concentration was reduced by 13%, from 7.6 mmol/L (SD ± 1) to 6.6 mmol/L (SD ± 0.7) after training (P< 0.05). The sum of the 3-hour postprandial glucose AUC for breakfast, lunch, and dinner was reduced by 30% (P<0.05). GLUT4 protein content was 369% higher after 2 weeks of training (Figure 2). The results if this study suggest that low-volume HIT improved 24-hr glycaemic control, and in particular glycaemic excursions after meals.

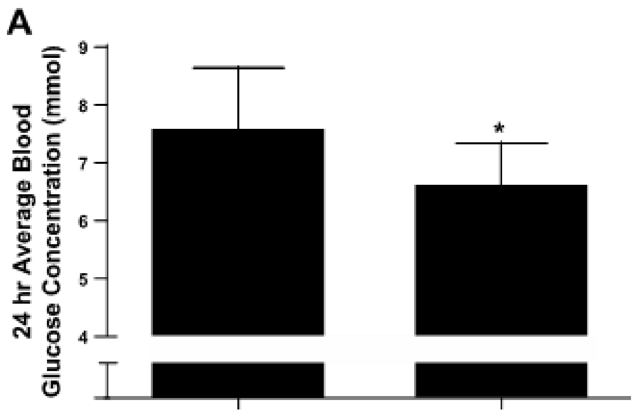

Figure 2. Two weeks of high-intensity interval training improves glycemic control. A: average blood glucose concentration measured by continuous glucose monitoring (CGM) over a 24-h period before (Pre) and after (Post) 2 wk of training. Posttraining CGM data was collected from ~48–72 h following the final training session. Values are means ± SD (N = 7). *P < 0.05. Data from Little et al. 2011. Low-volume high-intensity interval training reduces hyperglycemia and increases

muscle mitochondrial capacity in patients with type 2 diabetes. Journal of Applied Physiology 111: 1554–1560.

Gillen et al. (2012) measured postprandial glucose excursions and prevalence of hyperglycaemia in 7 people with T2DM following a single bout of HIT consisting of 10 x 60s cycle ergometer efforts at ~90% of maximal heart rate, interspersed with 60s rest under standardized dietary conditions. The actual exercise time came to a total of 10 minutes and resulted in a reduction in the sum of the 3-hour postprandial glucose AUC (P=0.01) and the proportion of time spent above10mmol/L in the 24-hour post-exercise period when compared to a non-exercising control day (Figure 3). Average 24-hour blood glucose was, however, not significantly reduced (P=0.16). The results of these two studies may have important clinical implications as postprandial blood glucose elevations are strongly implicated in the management of T2D and the development of cardiovascular disease (Ceriello 2003, Earnest 2009).

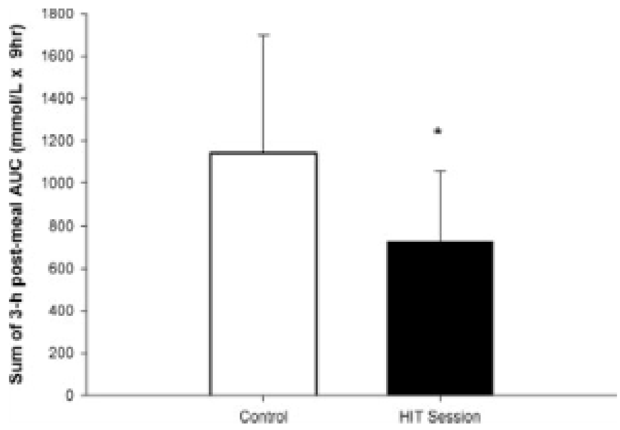

Figure 3. Sum of the 3-h post-meal blood glucose area under the curve (AUC) for lunch, dinner and breakfast assessed with continuous glucose monitoring (CGM) on the non-exercise control day and following acute high-intensity interval training (HIT). Values are mean ± s.d. (N = 7). * p = 0.01. Data from Gillen et al. 2012. Acute high-intensity interval exercise reduces the postprandial glucose response and prevalence of hyperglycaemia in patients with type 2 diabetes. Diabetes, Obesity and Metabolism 14: 575–577,

Conclusion And Practical Suggestions

Current exercise guidelines for T2DM and those at risk of developing T2DM recommend 150-210 minutes per week of moderate-intensity physical exercise. Given that most people fail to perform exercise of this duration because of the lengthy time commitments, HIT appears to be an extremely promising alternative for improving glucose control and increase exercise compliance due to the shortened time demands and more exciting nature of the interval type training when compared to traditional continuous exercise. Prudent advice to optimize glucose control based on the current available evidence suggests the performance of two to three HIT sessions per week in conjunction with several moderate-intensity continuous endurance or resistance exercise sessions on the remaining days of the week. The majority of evidence indicates HIT training protocols which involve either 10 intervals of 60 seconds duration interspersed with 60 seconds recover, eliciting ~90% HRmax or 4-6 intervals of 30 seconds duration at maximum capacity, with 4.5 minutes recovery appear to be optimal at the present time.

Suggestions For Further Research

Research on HIT and 24-hr glucose response in T2DM has demonstrated this training modality to be a potent, time-effective therapy to improve health with a relatively small time commitment. Further studies are needed with larger subject numbers, longer intervention lengths and various work to rest ratios to better identify the optimal long-term prescription of HIT for the fitness professional. Additionally, longer duration studies are needed to assess whether compliance and adherence to the exercise program is actually increased when subjects are prescribed HIT to follow by themselves in free living situations. Further research is also warranted to identify an optimal mode (i.e. cycling, running, rowing or other mode of exercise), optimal time of day (fasted or fed state) and the results of long term, 'real-life' training programs that utilize concurrent HIT, continuous aerobic and resistance training within the same session or week, that is routinely prescribed by fitness professionals.

Disclosure

The authors report no conflicts of interests in the work.

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Contribution

AGB and RL were both involved equally in the concept, literature search, review of literature and writing and approval of the final submission.

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