Preventive Medicine Reports 2 (2015) 314–318

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: http://ees.elsevier.com/pmedr

Intensive lifestyle intervention including high-intensity interval training program improves insulin resistance and fasting plasma glucose in obese patients☆

Guillaume Marquis-Gravel [a,c], Douglas Hayami [a,b,c], Martin Juneau [a,b,c], Anil Nigam [a,b,c], Valérie Guilbeault [a], Élise Latour [a], Mathieu Gayda [a,b,c,*]

[a] Cardiovascular Prevention and Rehabilitation Centre (ÉPIC), Montreal Heart Institute and University of Montreal, Quebec, Canada
[b] Research Center, Montreal Heart Institute and University of Montreal, Montreal, Quebec, Canada
[c] Department of Medicine, University of Montreal, Montreal, Quebec, Canada

ARTICLE INFO

Available online 28 April 2015

Keywords:
Intensive lifestyle intervention
Mediterranean diet counseling
High intensity interval training
Glycemic control
Obese

ABSTRACT

Objectives. To analyze the effects of a long-term intensive lifestyle intervention including high-intensity interval training (HIIT) and Mediterranean diet (MedD) counseling on glycemic control parameters, insulin resistance and β-cell function in obese subjects.

Methods. The glycemic control parameters (fasting plasma glucose, glycated hemoglobin), insulin resistance, and β-cell function of 72 obese subjects (54 women; mean age = 53 ± 9 years) were assessed at baseline and upon completion of a 9-month intensive lifestyle intervention program conducted at the cardiovascular prevention and rehabilitation center of the Montreal Heart Institute, from 2009 to 2012. The program included 2–3 weekly supervised exercise training sessions (HIIT and resistance exercise), combined to MedD counseling.

Results. Fasting plasma glucose (FPG) (mmol/L) (before: 5.5 ± 0.9; after: 5.2 ± 0.6; $P < 0.0001$), fasting insulin (pmol/L) (before: 98 ± 57; after: 82 ± 43; $P = 0.003$), and insulin resistance, as assessed by the HOMA-IR score (before: 3.6 ± 2.5; after: 2.8 ± 1.6; $P = 0.0008$) significantly improved, but not HbA1c (%) (before: 5.72 ± 0.55; after: 5.69 ± 0.39; $P = 0.448$), nor β-cell function (HOMA-β, %) (before: 149 ± 78; after: 144 ± 75; $P = 0.58$).

Conclusion. Following a 9-month intensive lifestyle intervention combining HIIT and MedD counseling, obese subjects experienced significant improvements of FPG and insulin resistance. This is the first study to expose the effects of a long-term program combining HIIT and MedD on glycemic control parameters among obese subjects.

Introduction

Lifestyle modifications refer to an integrated non-pharmacological approach aiming to reduce traditional cardiovascular risk factors. Current practice guidelines recommend integrated lifestyle modifications including weight control, exercise training, and nutritional modifications to improve cardiovascular risk factors and to promote health (Eckel et al., 2014; Haskell et al., 2007). Clinical research has so far mainly focused on the single components of lifestyle interventions (diet, exercise) to assess their respective effects on health (Estruch et al., 2013; Manson et al., 2002), despite the fact that they are recommended in combination (Eckel et al., 2014; Haskell et al., 2007). More recently, however, few randomized trials have tested them in combination (Fernandez et al., 2012; Group, T.L.A.R., 2013; Landaeta-Díaz et al., 2013).

Mediterranean diet (MedD) alone has been shown to reduce the incidence of major cardiovascular events and to be very effective in the reduction and long-term maintenance of body mass, blood pressure, and cholesterol levels in obese subjects with high cardiovascular risk (Estruch et al., 2013; Shai et al., 2008). High-intensity interval training (HIIT) involves bouts of exercise at an intensity close to 90–100% of VO_2max, interspersed with periods of active or passive recovery. The advised exercise modality in the most recent guidelines is generally moderate-to-vigorous intensity continuous exercise training (MICET), (Donnelly et al., 2009; Eckel et al., 2014; Haskell et al., 2007; Jensen et al., 2014) and very little details regarding HIIT protocols available are provided (Eckel et al., 2014; Haskell et al., 2007). Previous studies demonstrated that HIIT was more efficient to improve body composition, blood pressure, lipid composition, and VO_2peak than MICET

Acronyms: CAD, coronary artery disease; FPG, fasting plasma glucose; HIIT, high-intensity interval training; IFG, impaired fasting glycemia; MedD, Mediterranean diet; MICET, moderate-to-vigorous intensity continuous exercise training.

☆ Disclosures: none.

* Corresponding author at: Cardiovascular Prevention and Rehabilitation Centre (Centre ÉPIC), Montreal Heart Institute and Université de Montréal, 5055 St-Zotique Street East, Montreal, Quebec H1T 1N6, Canada. Fax: +1 514 374 2445.

E-mail addresses: Guillaume.Marquis.Gravel@umontreal.ca (G. Marquis-Gravel), Doug.Hayami@dal.ca (D. Hayami), Martin.Juneau@icm-mhi.org (M. Juneau), Anil.Nigam@icm-mhi.org (A. Nigam), Valerie.guilbeault@icm-mhi.org (V. Guilbeault), Elise.Latour@icm-mhi.org (É. Latour), Mathieu.Gayda@icm-mhi.org (M. Gayda).

http://dx.doi.org/10.1016/j.pmedr.2015.04.015
2211-3355/

(Drigny et al., 2013; Gremeaux et al., 2012; Helgerud et al., 2007; Tjønna et al., 2008). In addition, short-term studies (12 weeks) have shown that MedD combined with HIIT was superior to MedD alone to improve fitness, body composition, circulating endothelial progenitors, and health-related quality of life (Fernandez et al., 2012; Landaeta-Díaz et al., 2013), indicating a cumulative effect of both nutritional and exercise interventions.

Even among non-diabetic subjects, glycated hemoglobin (HbA_{1c}) is a strong predictor of hard coronary events in the general population (Pai et al., 2013), which makes glycemic control parameters interesting targets in primary prevention. Previous short-term randomized trials studies (12 to 16 week follow-ups) comparing HIIT vs. MICET have demonstrated either similar improvements of glycemic control parameters (fasting glycemia and insulin resistance), (Mitranun et al., 2014; Nybo et al., 2010) or superiority of HIIT for improvements of glycemic control parameters in overweight/obese patients (Mitranun et al., 2014; Tjønna et al., 2008). The effects of a long-term combination of HIIT with MedD on glycemic parameters are currently not documented in obese patients.

The first objective of this study was to assess the cumulative effects of HIIT and MedD in a long-term (9 months) lifestyle intervention program on glycemic control parameters, insulin resistance and β-cell function in obese subjects. The second objective was to describe the effects of this program on the same parameters in obese subjects according to their initial glycemic and insulin sensitivity statuses (diabetes, impaired fasting glycemia [IFG] or normal glycemia; insulin sensitive or resistant).

Methods

A retrospective study was performed at the Cardiovascular Prevention and Rehabilitation Center (ÉPIC) of the Montreal Heart Institute. Data from patients undergoing a 9-month clinical intensive lifestyle modification program (2009–2012), involving supervised HIIT training and MedD nutrition counseling, were retrospectively analyzed. According to the Institutional Review Board policy of the Montreal Heart Institute concerning retrospective studies, the present study was approved by the Ethical Committee of the Montreal Heart Institute.

Study population

Inclusion criteria at baseline were age over 18 years, and obesity defined as: 1) waist circumference ≥80 cm for women, ≥94 cm for men and 2) fat mass percentage >25% in men and >35% in women (Cornier et al., 2011). Detailed inclusion and exclusion criteria are provided in the Supplementary Methods section.

Exercise training program

Supervised exercise training sessions consisted of 2 to 3 supervised 60-min weekly sessions of HIIT (combined with resistance training). HIIT prescription was based upon the results of the baseline maximal treadmill exercise test and estimated maximal aerobic power. HIIT sessions were performed on ergocycle (Precor, model 846i, USA) under supervision of a kinesiologist and consisted of a 5-min warm-up at 50 W, followed by two sets of 10 min of repeated bouts of 15 to 30 s at 80% of maximal aerobic power interspersed by 15 to 30 s periods of passive recovery, and a 5-min cool down at 50 W. The targeted Borg rating of perceived exertion (RPE) was set at 15 during the exercise sessions. The two 10-min periods were separated by a 4-min passive recovery. Total exercise time was 34 min per HIIT session. Resistance training was prescribed and performed under supervision of a kinesiologist, and consisted of 20 min of circuit weight training performed with free weights and elastic bands adapted to each patient's capacity. For each muscle group, patients performed 1 set of 15 to 20 repetitions, followed by a 30-s rest period, at a target RPE of 15. Subjects were encouraged to perform 1 or 2 additional unsupervised continuous moderate intensity sessions per week, such as walking and/or cycling (45-min duration, Borg scale level averaging 12–14) outside or inside the center.

Nutritional counseling intervention

All subjects underwent 5 individual meetings with a dietician in our center. The first visit was used to obtain data on eating habits and motivation, and to provide the principles of the MedD. Details of the nutritional counseling are exposed in the Supplementary Methods section.

Statistical analysis

Statistical analysis was performed with SPSS® Statistics 20.0 (IBM®, Armonk, NY). Continuous variables are expressed as mean ± standard-deviation. Categorical variables are expressed as frequencies (percentage). For continuous variables, statistical differences in all subjects were evaluated by an ANOVA with repeated measure (time). Statistical differences in the sub-groups of obese subjects (insulin resistant and sensitive; diabetics, IFG and normal fasting plasma glucose [FPG]) were evaluated by a 2 way ANOVA (group and program). A post hoc test (Bonferroni) with a P value ≤ 0.05 was used to localize differences. Insulin resistance was defined as an HOMA-IR score ≥2.6 (Ascaso et al., 2003).

Results

Baseline characteristics

Baseline characteristics are shown in Table 1. Seventy-two obese subjects were included, from 2009 to 2012. Forty-three subjects (59%) had a normal FPG (<5.6 mmol/L), twenty-two subjects (30%) had an IFG (FPG: 5.6–6.9 mmol/L) and seven subjects were diabetics (FPG ≥7.0 mmol/L). Insulin resistance (HOMA-IR ≥2.6) was present in 41 subjects (57%).

Table 1
Baseline characteristics of the obese subjects.

Age (years) (mean ± SD)	53 ± 9
Gender (female/male)	(54/18)
Body mass (kg) (mean ± SD)	97 ± 18
Body mass index (kg/m^2) (mean ± SD)	35.3 ± 5.3
Waist circumference (cm) (mean ± SD)	111 ± 13
Total fat mass (kg) (mean ± SD)	41 ± 11
Trunk fat mass (kg) (mean ± SD)	21 ± 5
Diabetes	7 (10%)
Hypertension	22 (31%)
Current smoking	4 (6%)
Dyslipidemia	26 (36%)
VO_2peak (METs) (mean ± SD)	8.6 ± 1.6
Total cholesterol (mmol/L) (mean ± SD)	5.0 ± 1.1
LDL-cholesterol (mmol/L) (mean ± SD)	3.0 ± 1.0
HDL-cholesterol (mmol/L) (mean ± SD)	1.4 ± 0.3
Triglycerides (mmol/L) (mean ± SD)	1.4 ± 0.7
Medication	
Antiplatelet agents	14 (19%)
Beta-blockers	5 (6.9%)
Calcium channel blockers	6 (8.3%)
ACE inhibitors	7 (9.7%)
Angiotensin receptor blocker	16 (22%)
Statins	20 (27%)
Oral antidiabetic	3 (4%)
Parenteral insulin	0 (0%)

FPG: fasting plasma glucose; HOMA-IR: Homeostasis Model Assessment for insulin resistance; SD: standard-deviation.
Study conducted at the EPIC Center of the Montreal Heart Institute (2009–2012).