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Impact of exercise on insulin sensitivity and glucose metabolism

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Abstract
This correlational study looks at the relationship between two variables, which are the levels of insulin sensitivity and the metabolism of glucose among diabetic patients with emphasis on the impacts of exercise on the two variables. The main objective of the research was to give a comprehensive assessment of the insulin sensitivity in lean and obese subjects diagnosed with high levels of glucose tolerance. The research was carried out in such a way that hyperinsulinemic-euglycemic clamp procedure was carried out with the stable isotopically-labeled tracer infusions among 400 patients in India. The body mass index was set at 36 kg/m^2. The 26 lean sucrose levels for the patients were set at 22.5 kg/m^2 for patients with normal glucose tolerance. Insulin was infused at varied levels to achieve the desired concentrations. The results showed that among obese subjects, the palmitate and glucose R_a levels in plasma decreases with the increase in plasma insulin concentrations.

Keywords: insulin sensitivity, metabolism, diabetic patients, glucose tolerance

Introduction

Insulin sensitivity is considered to be highly correlated with the levels of glucose metabolism among diabetic patients (Blackwood, 2017) [4]. Exercise is an integral component of the lifestyle management of type 2 diabetes mellitus (T2DM) [1]. Clarifying the impact of vigorous exercise in vivo insulin action and metabolism of glucose is essential at if involves the clarification of the intervening effects of concomitant alterations in body weight and the composition as well as the residual impacts of an acute exercise session (Bostad, 2015) [5]. Obesity is the major predisposing factor in the development of insulin resistance. If untreated, the progressive hyperglycemia and subsequent compensatory hyperinsulinemia seen in insulin-resistant individuals will lead to beta-cell failure and the onset of type 2 diabetes (T2D) [2]. Poor physical fitness is a strong indicator of an increased risk of developing diabetes. Similar to subjects diagnosed with type 2 diabetes and impaired glucose tolerance, healthy and glucose-tolerant offspring have been characterized by decreased physical capacity [maximal oxygen uptake (VO2 max)] even though the level of habitual physical activity was comparable in these groups. The cause of decreased VO2 max in type 2 diabetic subjects and their relatives has not yet been fully determined [3]. The research involved 100 lean 100 obese, and 60 diet-controlled type 11 diabetic men who underwent training of 8 weeks on a cycle ergometer with 5h/wk at approximately 70% of the maximal oxygen uptake (VO2 max). It was evident that the body composition and weight were kept at a normal pace by refeeding energy expended at each session.

Methodology

A total of 100 lean (BMI 20 kg/m^2) and 40 obese (30kg/m^2) sedentary 1 hour of exercise per week subjects who were involved in the study. Prior to the study an incremental treadmill exercise test was performed to determine each subjects' maximal aerobic capacity (VO2max). All volunteers then completed a fully supervised aerobic exercise training: 1 h per day, Over 80% of the exercise was performed on a treadmill, but in order to provide some variety to the workout, subjects were allowed to alternate between a treadmill and cycle ergometer. Training was initiated at 60% of their maximal heart rate (HRmax; _50% VO2max), gradually increasing their intensity so that by per week they were exercising at 80-85% of HRmax (_70% VO2max) [2]. The lean and obese subjects were to undergo a two-stage HECP in collaboration with the stableisotopically-labeled tracer infusions as part of the initial studies (Thangasami *et al.*, 2015) [18]. All the subjects were also required to complete a comprehensive medical evaluation that was encompassed with the history and the physical examinations, hemorrhage tests, and 2-hour oral glucose tolerance tests. The exclusion criteria were such that no participant had impaired fasting glucose or diabetes or had taken medications that would influence the metabolism of lipids and glucose (Son *et al.*, 2017) [17]. Moreover, all participants were required to sign an informed consent form before qualifying for the study, which was approved by the college administration.

The composition analysis was determined by carrying out an analysis of the fat-free body mass (FFM) that was determined by the use of the dual-energy X-ray absorptiometry. The subjects were admitted to the unit of clinical research in South India (Colberg *et al*., 2016) [7]. After 24 hours, one catheter was put into the forearm as a way of infusing the isotopically labeled tracers and insulin, while the second catheter was put into the radial artery in the contralateral hand to extract the blood samples (Son *et al*., 2017 [17]. Arterialized blood samples were obtained by inserting a catheter into the hand vein that was heated to 50^0c whenever radial cannulation would prove to be the impossibility. There was a primed continuous infusion that was carried out, where the priming dose was to be maintained at 22.5 mmol per kg and an infusion rate of 0.25 mmol per kg per minute. In the obese subjects, a primed continuous infusion was also maintained at of $2,3^{-2}$ glycerol and at a priming dosage of 1.2 mmol per kg. The infusion rate was kept at 0.8 mmol per kg per minute among these patients.

Among all the selected lean subjects for this project and the obese subjects, insulin was required to be infused at the rate of 7 mU per square meters body surface area per minute. The infusion was to be initiated with a priming dosage of 30 mU. M^{-2}. The infusion rates were altered accordingly to allow for the assessment of the adipose tissue and sensitivities of insulin in the liver (Denou *et al*., 2016) [8]. The first rates of infusion of insulin were meant to suppress adipose tissue lipolysis and the submaximal production of hepatic glucose following the exercise. The second high-dose insulin infusion rates were carried out to stimulate the uptake of insulin in muscles following the exercise (Gaitan *et al*., 2017) [9]. On the other hand, the euglycemia levels of 5 mmol/L were maintained through the infusion of 10% dextrose that was enriched with 3% glucose at variable rates.

Sample Analysis

The measurements for plasma glucose were carried out using the automated glucose analyzer. Plasma insulin and C-peptide concentrations were also taken using the chemiluminescent immunoassay (Canfora *et al*., 2015) [6]. The gas chromatography was carried out to determine the plasma FFA concentrations, while the electron impact ionization gas chromatography was used in the analysis of the plasma glucose.

Calculations

The Isotopic steady-state conditions required were reached through the final 1 hour of basal period in the first and second stages of clamp procedure. The Steele's equation for steady-state conditions was applied in determining the exogenously infused dextrose and tracers of glucose (Son *et al*., 2017) [17]. The kinetics of palmitate and glycerol were expressed regarding micro molecules per kilogram of fat mass for every minute per kilogram of FFM, which led to the determination of the FFA index availability for lean tissues that use fatty acids to burn down calories following an exercise.

Data Analysis

The statistical analyses were carried out using SPSS version 17.0, SPSS, Florida, IL. The results were presented regarding the normally distributed data sets or means as well as medians that showed the skewed data sets (Sargeant *et al*., 2018) [6].

Subject characteristics

The characteristics of the different participants were recorded in the table shown below. The results show that the basal plasma glucose concentrations are not significantly different among the lean and obese subjects, even though the mean plasma insulin concentration is greater among the obese participants as compared to the lean subjects (Son *et al*., 2017) [17]. The HDL cholesterol levels were also found to be lower, while the LDL cholesterol levels were not varied at all between the subjects chosen for this analysis.

Table 1

Characteristics	Lean	Obese
n (male/female)	260 (200/60	140 (90/50)
BMI kg/m2)	25	35
Body fat (kg)	20	39
FFM (kg)	42	60
Exercise plasma glucose (mmol/L)	5	5
LDL Cholesterol (mmol/L)	3	3
HDL Cholesterol (mmol/L)	1.5	1

The graph below depicted the levels of suppression of glycerol, where the white bars represent these levels of suppression, while the repression of palmitate is shown by the hatched bars (Hemati *et al*., 2014). The black bars represent glucose repressions for the insulin infusions for the obese subjects.

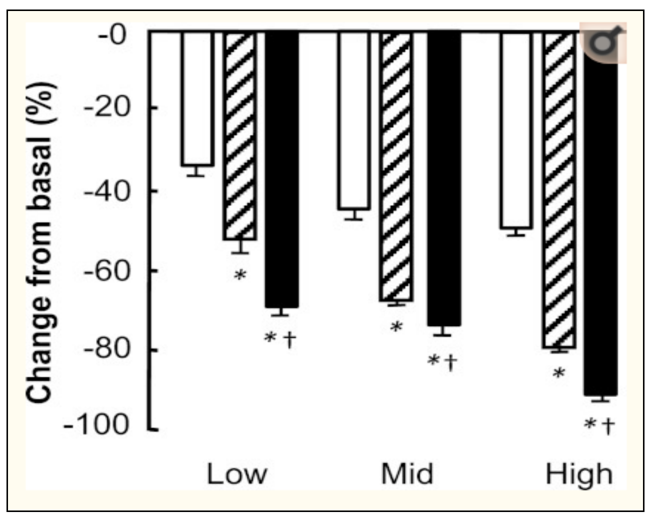

Fig 1: suppression of glucose

Discussion

The kinetics of glucose depicted that the endogenous glucose levels were lowered progressively with the increase in the plasma insulin concentrations (Morrison, 2018). The results also show that the suppression of glucose increased considerably from 70% during low-dosage insulin infusion to 90% during high-dose insulin infusion (Klimentidis *et al*., 2014). The graph below shows the progressive changes in the levels of endogenous glucose.

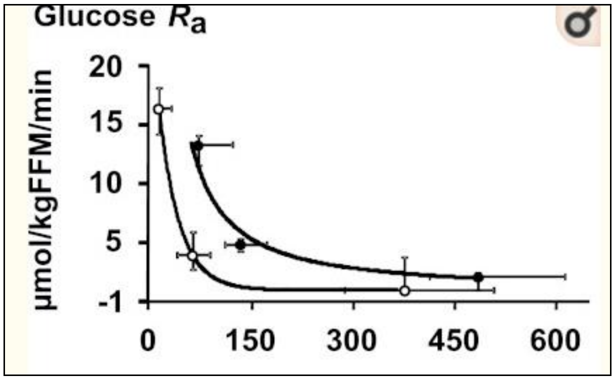

Fig 2: Glucose Kinetics

The suppressions of palmitate and glucose were also found out to be greater among the lean subjects as compared to those who were obese during lower levels of insulin concentrations (Son *et al*., 2017). However, the ranges were the same in both groups upon the increase of the insulin levels or within the normal physiological range as shown below:

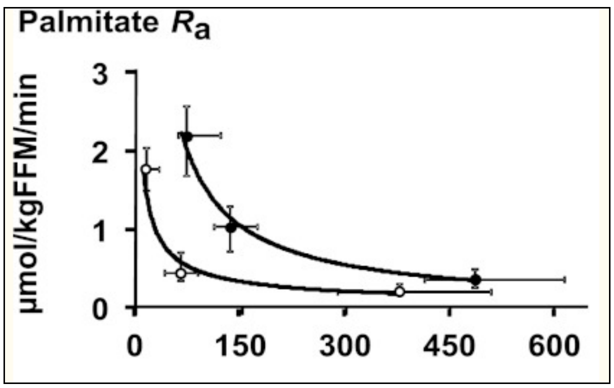

Fig 3

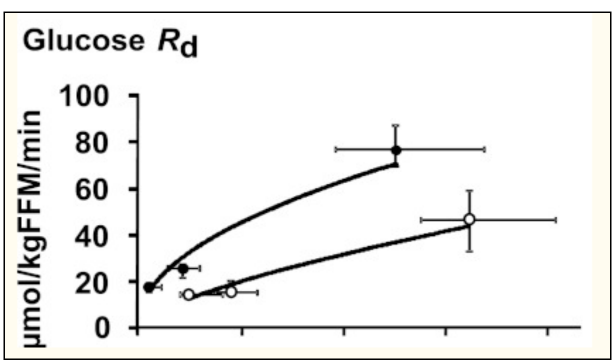

Fig 4

The resistance of insulin in the liver or the suppression of production of glucose, the stimulation of its uptake and the suppression of lipolysis are found to be involved in the pathogenesis of most of the metabolic complications that are related to diabetes infection (Linke & Schuler, 2016) [12]. The sensitivities if insulin were evaluated during the basal post-absorptive conditions as well as evaluations across the physiological range of plasma insulin concentrations that were meant to stimulate the levels observed at postprandial conditions among the control and experimental groups (Son *et al*., 2017). The lean subjects were regarded as the control group, while the obese groups were considered as the experimental. The results correlate with the various literature findings that have shown that exercise improves the levels of glucose metabolism and does not improve the insulin sensitivity among the lean and obese diabetic patients.

Conclusion

The body weight, fat, and fat-free mass have been shown to change the following exercise among the obese patients, which is a clear indicator that physical exercise has the capability of improving the process of metabolism. On the other hand, insulin sensitivity is not significantly altered following exercise or training even though the basal hepatic glucose production is greatly reduced among diabetic patients. This implies that when the intervening effects of the last exercise bout or alterations in the body position are controlled, exercise leads to the increase in cardiorespiratory fitness and has no independent impact on the levels of action of insulin. The results showed that exercise did not lead to the improvement of the insulin resistance levels among obese patients. However, the metabolism of glucose was found out to improve consistently following constant exercise among the selected patients.

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