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Insulin Secretion in Obesity after Exercise

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Summary. Blood glucose and plasma insulin during glucose loads were measured in nine obese patients before and twice the days after a submaximal work of long duration. All subjects showed lower plasma insulin values the day after exercise. The insulin/glucose ratio was decreased indicating an increased insulin sensitivity. The effect could be demonstrated with the peroral as well as with the intravenous glucose test. The effect was remaining for four to six days after exercise in seven of the nine patients studied. The insulin concentration the day after exercise was well within the range of values of non-obese, non-exercising controls. No parallel lowering of plasma triglycerides was observed. It was concluded that an acute, submaximal, prolonged work produces a considerable decrease of plasma insulin levels during several days in hyperinsulinemic obese patients.

Sécrétion de l'insuline chez les obèses après exercice

Résumé. Le glucose sanguin et l'insuline du plasma ont été mesurés pendant des charges de glucose chez 9 malades obèses, d'une part, avant un exercice submaximal de longue durée, d'autre part, deux fois les jours après cet exercice. Tous les sujets ont montré une diminution des valeurs de l'insuline du plasma un jour après l'exercice. Le quotient insuline/glucose était réduit, montrant une augmentation de la sensibilité envers l'insuline. L'effet pouvait être démontré aussi bien par le test oral au glucose que par le test intra-veineux. L'effet durait 4 à 6 jours après l'exercice chez 7 des 9 malades étudiés. La concentration de l'insuline un jour après l'exercice restait bien dans la variation des valeurs des témoins non-obèses et sans exercice. On n'observe aucune diminution parallèle des triglycérides du plasma. En conclusion, un exercice intense, submaximal et prolongé provoque une réduction considérable du taux de l'insuline du plasma durant plusieurs jours chez les malades obèses hyperinsuliniques.

Insulinsekretion bei Übergewichtigen nach Arbeit

Zusammenfassung. Bei 9 übergewichtigen Patienten wurde vor und zweimal pro Tag nach einer untermaximalen, lang dauernden Arbeit der Blutzucker und das Plasmainsulin während einer Glucosebelastung gemessen. Alle Patienten hatten am Tage nach der Arbeitsbelastung einen geringeren Plasmainsulingehalt. Der verminderte Insulin/Glucose-Quotient deutet auf eine erhöhte Insulinempfindlichkeit hin. Dieser Effekt wurde sowohl mit dem oralen als auch mit dem intravenösen Glucosetoleranztest gefunden und hielt bei 7 von 9 Patienten 4—6 Tage nach der Arbeitsbelastung an. Die Insulinkonzentration am Tage nach der Arbeitsbelastung lag innerhalb der Streuungsbreite von normgewichtigen, nicht arbeitenden Kontrollen. Die Plasmatriglizeride waren nicht vermindert. Daraus wurde geschlossen, daß eine akute, untermaximale, lang dauernde Arbeit eine über mehrere Tage beträchtliche Verminderung des Plasmainsulinspiegels bei hyperinsulinämischen, übergewichtigen Patienten bewirkt.

Key words: Obesity, exercise, insulin, triglycerides, glucose tolerance.

Introduction

The increased secretion of insulin in obesity [1, 2, 3] is considered as a homeostatic response to decreased glucose utilization [4] and decreased insulin sensitivity [1, 5]. Hyperinsulinism has been implicated in the pathogenesis of obesity [6], maturity onset diabetes [3], certain types of hyperlipemia [7] and of atherosclerotic disease [7]. A lowering of abnormally high insulin levels by increasing glucose utilization and decreasing insulin resistance might therefore be of importance in prevention of these disorders.

Physical training decreases plasma insulin concentration in non-obese subjects [8, 9] and in spontaneous obesity [10]. A decrease in body weight [8] or body fat, and fat cell size [10] does not seem to be a prerequisite for this effect. The explanation of these findings is not clear, although a local effect in the trained muscle has been suggested [10]. The purpose of the present work was to study the role of acute exercise on insulin response to a glucose load in obese subjects, and to evaluate the duration of a change in response.

Material and methods

Nine obese patients, 5 women and 4 men, were selected on the basis of sedentary habits and willingness to cooperate for prolonged physical work on a bicycle ergometer. Mean age was 32 years (range 18—53 years) and mean weight 108 kg (range 83—144 kg). The patients were asked not to restrict their diet, and to continue a sedentary life during the period of investigation. The design of the exercise was intended to cause, as far as possible, a depletion of glycogen in the working muscles, which occurs in normal individuals after about one hour at 950 kpm/min [11]. This work was too strenuous for the sedentary obese group examined, and therefore the load was decreased. The exercise was performed on an electrically braked bicycle ergometer (Elema Schönander, Sweden). The work load was 400—900 kpm/min, at a heart rate of 140—176/min, for 60 min. Maximal oxygen consumption capacity was determined afterwards with stepwise increasing workload and examinations of exhaled air in Douglas bags. The work-load was found to be

$70 \pm 4\%$ (mean $\pm$ SEM) of maximal oxygen consumption capacity.

In two men, L.T. (31 years, 144 kg) and B.B. (35 years, 128 kg), the effect of exercise on insulin secretion was studied by the use of a peroral glucose load. Blood glucose [12] and heparin plasma immunoreactive insulin [13] were determined in these two men before and 30, 60, 90 and 120 min after the ingestion of 100 g of glucose. In the other seven subjects an intravenous glucose tolerance test (IVGTT) was performed, with 25 g glucose injected during three minutes. Blood glucose in capillary blood was analyzed [12] before and at 20, 25, 30, 40, 50, 60 and 70 min after glucose administration. Glucose fractional turnover rate was estimated as K-value [14]. Insulin [13] was determined before and 30 and 60 min after injection. An "insulinogenic index" was calculated as the sum of all determined insulin values divided by the sum of glucose values obtained at the same times (Peroral: 0, 30, 60, 90, 120 min. IVGTT: 0, 30, 60 min). The glucose tolerance tests were performed after an over-night fast, before exercise (average 4 days), the day after exercise and 4 to 6 days after exercise in all subjects. Serum triglycerides [15] and cholesterol [16] were also determined.

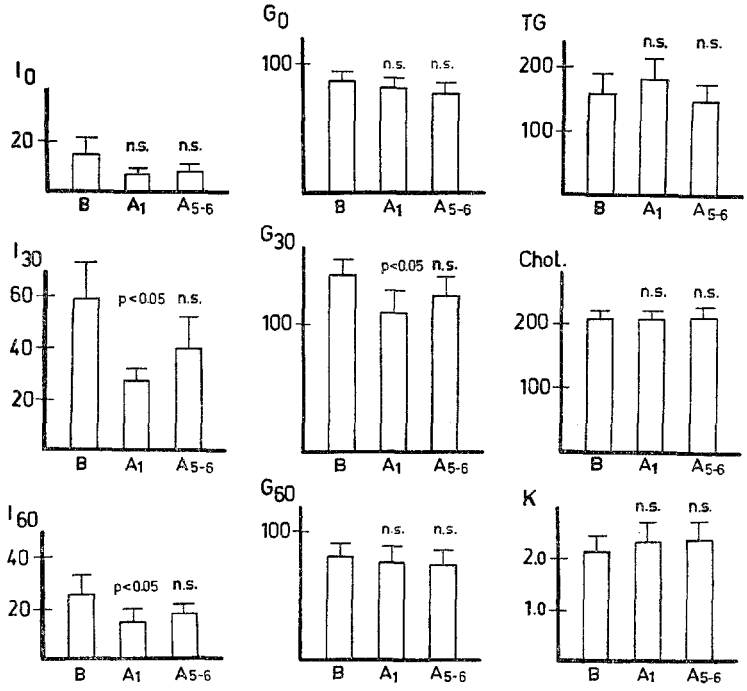

Fig. 1. Results of determinations (mean $\pm$ SEM) of glucose, insulin in obese patients before and at different times after exercise. (B = before exercise. A_1 = the day after exercise. A_{5-6} = five to six days after exercise. *TG* = trigyclerides mg/100 ml, Chol. = cholesterol mg/100 ml. K = K-value of IVGTT. I_0, G_0 = insulin μU/ml, and blood glucose mg/100 ml, before IVGTT. I_{30}, G_{30} = insulin and glucose 30 min after IVGTT. I_{60}, G_{60} = insulin and glucose 60 min after IVGTT)

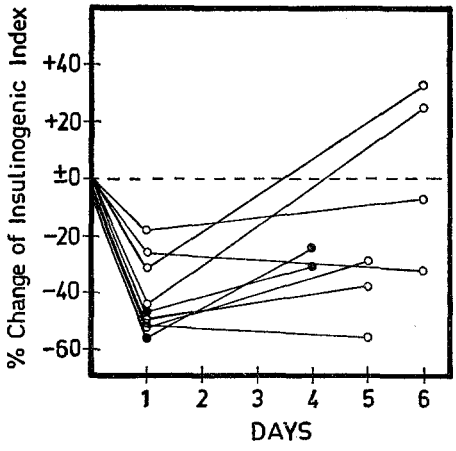

Fig. 2. Change of insulinogenic index the days after exercise investigated by peroral (●—●) and intravenous (○—○) glucose tolerance test

Results

Fig. 1 shows that one day after exercise insulin values were lower 30 and 60 min after intravenous glucose administration. Basal insulin values were not significantly reduced (from 14.6 ± 5.7 μU/ml before to 7.6 ± 2.0 μU/ml one day after work, means $\pm$ SEM). The patients with highest insulin values before exercise showed a pronounced decrease (44 to 11 and 22 to 6 μU/ml). Glucose values were significantly lower only at 30 min. Triglyceride, cholesterol or glucose fractional

turn-over rate (K-value) did not change. Five or six days after exercise there were no significant changes.

The individual changes in the ratio of sum of insulin/sum of glucose values during IVGTT are shown in Fig. 2. All decreased one day after exercise. The mean decrease was 39% ($p < 0.05$). Three of these subjects still showed reduced insulinogenic indices five days after exercise (12%, 38%, 66%). The other four were investigated six days after exercise and insulinogenic indices were less than the original values in two subjects, and higher in two subjects.

Discussion

Plasma insulin concentration during glucose load and the insulin/glucose ratios decreased for a few days in most of the patients studied and for at least one day in all patients. The great variation of insulin response in the days after exercise makes calculation of average duration difficult. The results indicate an increased insulin sensitivity and are in good agreement with the well-known observation that exercise decreases the exogenous insulin requirement in diabetic patients, not only during, but also a day after exercise [17].

It has previously been reported that obese patients show decreased insulin response to glucose load after training and it was considered possible that part of thiss effect might be due to the last exercise occasion [10]. This suggestion is supported by the observations reported in the present work.

It was observed that the effect of exercise on plasma insulin appeared to be more pronounced the higher the initial plasma insulin value. It might therefore be questioned whether this decrease is found only in hyperinsulinaemic conditions. Although the resulting fasting insulin concentrations obtained the day after exercise seemed to be well within the range of those found in control populations [18], it is not possible to state that acute exercise of the type tested in the present work actually normalizes plasma insulin concentration and insulin resistance in obesity, because data from similarly treated controls are so far missing. The present investigation demonstrated, however, that acute, prolonged, submaximal work has a major effect on plasma insulin levels for several days after exercise in obese hyperinsulinaemic patients.

Prolonged physical exercise decreases plasma triglycerides [19] and there is evidence suggesting that the lowering effect of training on triglycerides is mainly an effect of the last bout of exercise [20]. The triglyceride concentration was not lowered in the present study. The lack of agreement in results might be caused by differences in pre-exercise levels of triglycerides or duration and intensity of the work.

The explanation of the effects of physical exercise on plasma insulin concentration in obesity is not known, but some evidence pertinent to this question is available. A humoral factor enhancing glucose uptake in several tissues and which is released after exercise from contracting muscle tissue has been proposed by Goldstein [21], but has been questioned in other studies [22]. The role of other humoral factors with effects opposing that of insulin is not known.

It has been demonstrated that carbohydrate feeding plays an important role for regulation of plasma insulin concentration [23]. It seems rather unlikely that the pronounced decrease of insulin levels and of insulin resistance the day after exercise should be explainable by such factors as a decrease of carbohydrate intake even though it was not possible to control this adequately in these studies on out-patients.

The localization of the effect of exercise on plasma insulin concentration is of considerable interest. Insulin insensitivity or resistance in obesity has been demonstrated in muscle [4, 5] and in adipose tissue [24], but it may well also be present in other tissues such as liver, because gluconeogenesis seems to be elevated in obese patients [25] in spite of the hyperinsulinemia frequently seen in this condition. It is not known whether exercise has any effect on adipose tissue insulin resistance, but whether it does or not it is probably of little importance for the plasma insulin concentrations, because the quantitative role of adipose tissue for glucose assimilation is of minor significance [26]. Effects of physical exercise on liver gluconeogenesis during the days after work are apparently not known, but might offer an explanation to the results. Exercise produces, however, several changes in the working muscle lasting some days after exercise. Such local changes in substrate concentrations [11, 27] and enzymic activities [28] may well contribute to an enhancement of muscle glucose uptake and thereby a decrease of insulin requirement.

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