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ORIGINAL

Blood glucose monitoring during aerobic and anaerobic physical exercise using a new artificial pancreas system☆

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KEYWORDS
Artificial pancreas;
Type 1 diabetes;
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Abstract
Aim: To assess an artificial pancreas system during aerobic (AeE) and anaerobic exercise (AnE).
Methods: A pilot clinical trial on five subjects with type 1 diabetes (four males) aged 37 ± 10.9 years, diabetes diagnosed 21.2 ± 12.2 years before, insulin pump users, and with a mean HbA_{1c} level of 7.8 ± 0.5%. Every subject did three AeE and three AnE sessions. Blood glucose levels were monitored by the artificial pancreas system during exercise and up to 4 h later. Before the start of exercise, 23 g of carbohydrates were administered orally.
Results: The mean glucose level was 124.0 ± 25.1 mg/dL in the AeE studies and 152.1 ± 34.1 mg/dL in the AnE studies. Percent times in the different glucose ranges of 70–180, >180, and <70 mg/dL were 89.8 ± 18.6 and 75.9 ± 27.6%, 7.7 ± 18.4 and 23.2 ± 28.0%, and 2.5 ± 6.3 and 1.0 ± 3.6% during the AeE and AnE sessions, respectively. Only six rescues with carbohydrates (15 g) were required during the studies (four in AeE and two in AnE). Total insulin dose during the 5 h of the study was 3.1 ± 1.0 IU in the AeE studies and 3.5 ± 1.3 IU in the AnE studies.

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Conclusions: Blood glucose response to AeE and AnE exercise is different. The evaluated artificial pancreas system appeared to achieve effective and safe blood glucose control during exercise and up to 4 h later. However, new control strategies that minimize patient intervention should be designed.

PALABRAS CLAVE
Páncreas artificial;
Diabetes tipo 1;
Ejercicio

Control de la glucemia durante el ejercicio físico aeróbico y anaeróbico mediante un nuevo sistema de páncreas artificial

Resumen
Objetivo: Evaluar de forma exploratoria un sistema de páncreas artificial durante la realización de ejercicio aeróbico (EAe) y anaeróbico (EAn).
Métodos: Ensayo clínico piloto con 5 sujetos con diabetes tipo 1 (4 hombres) de 37 ± 10,9 años, 21,2 ± 12,2 años de evolución de la diabetes tipo 1, usuarios de infusor de insulina y una HbA_{1c} de 7,8 ± 0,5%. Cada uno de los pacientes realizó 3 estudios de EAe y 3 de EAn. El control de la glucemia se realizó mediante el algoritmo de páncreas artificial durante el ejercicio y las 4 h posteriores al mismo. Previo al inicio del ejercicio físico se administraron 23 g de hidratos de carbono.
Resultados: La media de glucosa fue de 124,0 ± 25,1 mg/dL en los estudios de EAe y de 152,1 ± 34,1 mg/dL en los de EAn. Los porcentajes de tiempo en 70-180, > 180 y < 70 mg/dL fueron: 89,8 ± 18,6% y 75,9 ± 27,6%; 7,7 ± 18,4% y 23,2 ± 28,0%; 2,5 ± 6,3% y 1,0 ± 3,6% durante el EAe y EAn, respectivamente. Únicamente fueron necesarios 6 rescates con 15 g de hidratos de carbono en el total de los estudios (4 en EAe y 2 en EAn). La dosis total de insulina durante las 5 h de estudio en los estudios de EAe fue de 3,1 ± 1,0 UI y de 3,5 ± 1,3 UI en los EAn.
Conclusiones: La respuesta glucémica al EAe y al EAn es diferente. El sistema de páncreas artificial evaluado parece controlar de forma eficaz y segura la glucemia durante el ejercicio y las 4 h posteriores al mismo, aunque es necesario el diseño de nuevas estrategias de control que minimicen la intervención del paciente.

Introduction

In recent decades, therapeutic advances in the management of type 1 diabetes mellitus (DM1) have significantly increased patient life expectancy. However, individuals with DM1 have a 4–8-fold increased risk of developing cardiovascular disease compared with individuals without diabetes.

Physical exercise has shown multiple benefits in terms of diminished cardiovascular risk, including an improved lipid profile, reduced body weight and fat, and lower blood pressure. The most recent clinical guidelines therefore recommend regular physical exercise in patients with DM1.[1] However, it is also widely known that blood glucose management during and after physical exercise is complex regardless of the treatment modality used, since exogenous insulin administration is unable to mimic the complex physiological system involved in blood glucose regulation.

Multiple factors such as the type of exercise, its duration and intensity, the physical condition of the patient, the time of day of exercise, or the performance of exercise or not during the previous days all condition the glycemic response to exercise in patients with DM1. The implication of so many factors means that predicting blood glucose behavior in response to physical exercise is a highly complex matter. As a result, it is difficult to standardize therapeutic management during and after exercise. Nevertheless, some recent guidelines[2] have summarized the information obtained from a range of studies analyzing the physiological response to exercise in patients with DM1. This has provided general advice on the management of blood glucose during the different types of physical exercise, which subsequently needs to be individualized.

Artificial pancreatic systems use the interstitial blood glucose values collected by a continuous monitoring sensor, with an automatic mathematical algorithm-based calculation of the insulin dose to be administered in order to maintain blood glucose values within a target range. These systems have been shown to improve glycemic control in patients with DM1 in home-based studies as compared to conventional systems in which the patients themselves are responsible for taking treatment decisions.[3,4] However, unpredictable and rapidly varying changes in insulin requirements associated with physical exercise in patients with DM1 pose a challenge for artificial pancreatic systems. In particular, the initial decrease in glucose levels usually observed after the start of aerobic exercise (AeE) poses a challenge for unihormonal artificial pancreas systems, since their only possible action is to arrest insulin infusion, and if this is done