CLINICAL RECOMMENDATIONS FOR THE PRACTICE OF SPORTS IN PEOPLE WITH DIABETES MELLITUS (*RECORD* GUIDELINE). UPDATE 2021

DIABETES AREA . SPANISH SOCIETY OF ENDOCRINOLOGY AND NUTRITION (SEEN)

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UPDATE 2021

RECORD GUIDELINES 2021 • DIABETESEEN •

1 EFFECTS OF EXERCISE IN T1D

A. Prolonged **moderate-intensity aerobic** exercise: ↑ **hypoglycaemia risk**

B. **High-intensity** exercise: ↑ **hyperglycaemia risk** (with low insulin levels)

2 MEDICAL ASSESSMENT BEFORE EXERCISE

A.

Bear in mind:

1. Degree of metabolic control
2. Physical examination
3. Are there any complications?
4. EKG
5. Risk of hypoglycaemia

B.

Consider stress test **IF:**

1. >35 years old
2. >25 years and T2D diagnosed +10 years
3. >25 years and T1D diagnosed +15 years
4. CVRF
5. Microvascular complications
6. PAD
7. Autonomic neuropathy

CVRF: Cardiovascular risk factors; **PAD:** Peripheral arterial disease; **EKG :** Electrocardiogram.

3 FOOD

Objectives: ensure macro- and micronutrients intake, glycogen maintenance, fluid and electrolyte balance

A. Pre-exercise

MACRONUTRIENTS	**Carbohydrates**	3-5 hours exercise/week : 4-5 g CH/kg/day 5-10 hours exercise/week : 5-7 g CH/kg/day 10-15 hours exercise/week : 7-8 g CH/kg/day >15 hours exercise/week : 8-10 g CH/kg/day For extreme exercise/competition, 12 g CH/kg/day might be necessary Prioritise low-GI foods No current evidence on the benefit of very low-CH diets (<140 g/day) for athletes with T1D
	Proteins	1.2-1.6 g/kg/day (prioritise high-biological value proteins; greater intake for strength sports and prolonged aerobic exercise)
	Fats	20-35% total energy volume (≤20% fat intake provides no benefits)

Ensure hydration + micronutrients

B. During exercise: CH before hands, depending on blood glucose/trend arrow and duration of exercise/blood glucose at end of exercise

CH supplementation. Approximate levels, adjust in each case		
	Basal insulin levels (T1D/T2D bolus administered every 2 hours; T2D treated with secretagogues)	**High insulin levels (T1D/T2D prior bolus in last 2 h)**
Up to 30 ' exercise	If blood glucose <90 mg/dL, ingest 10-20 g GL	15-30 g GL to prevent/treat hypoglycaemia
30-60 ' exercise	Low-moderate intensity (aerobic): 10-15 g GL/h	15-30 g GL/30 minutes to prevent hypoglycaemia
	High intensity (anaerobic): do no supplement except when blood glucose <90 mg/dL with 10-20 g GL	
60-150 ' exercise	30-60 g GL / hour	Up to 75 g GL/hour
Exercise >150 '	60-90 g GL+ SRCH/hour, adjust insulin if required	60-90 g GL+ SRCH/hour, adjust insulin if required

Ensure hydration

C. Post-exercise: If blood glucose <120 mg/dL: take 15-20 g SRCH. CH replacement in competing athletes. Ensure hydration

CH: Carbohydrates; **GI:** Glycaemic index; **GL:** Glucose; **SRCH:** Slow release carbohydrates

4 BLOOD GLUCOSE

A. Prioritise use of glucose monitor/increase number of blood glucose tests

B. Follow manufacturer's instructions

C. Recommendations:

1

Alarms

- Hypoglycaemia 100 mg/dL
- Hyperglycaemia >180 mg/dL

2

TIR during exercise: TIR 90-180 mg/dL (126-180 mg/dL for prolonged aerobic exercise)

- Adjust for high hypoglycaemia risk
- Check blood glucose depending on intensity and duration

3

90 minutes post-exercise TIR 80-180 mg/dL (with low hypoglycaemia risk)

- Check blood glucose 15-30 minutes
- Assess modifying hypoglycaemia alarm

TIR: time in range

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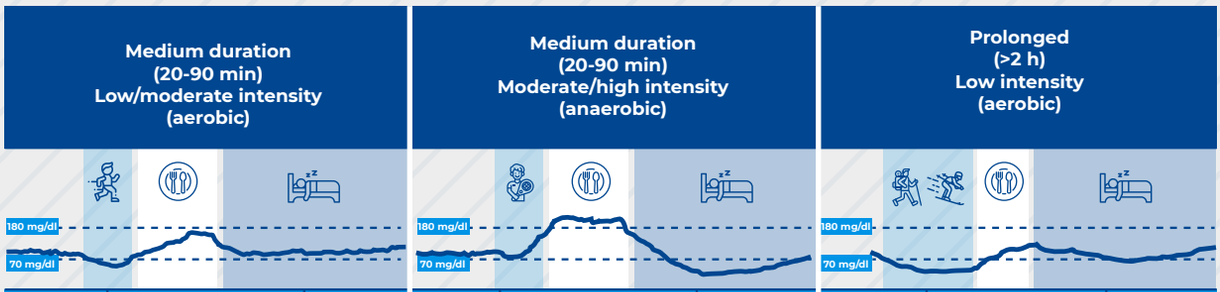
5 PHARMACOLOGICAL TREATMENT

A. Recommendations for adjusting basal / intermediate (excluding degludec) and rapid preprandial post-exercise insulin.



Basal pre-exercise	Preprandial post-exercise		Basal post-exercise
	Trend	Adjustment	
- 0-30%	↗	-25%	= /-20%
	→	-50%	
	↘	-75% / -100%	

Basal pre-exercise	Preprandial post-exercise		Basal post-exercise
	Trend	Adjustment	
- 20%	↗	=**	- 20-30%
	→	=**	
	↘	-25% / -50%	

Basal pre-exercise	Preprandial post-exercise		Basal post-exercise
	Trend	Adjustment	
- 30-50%	↗	-25%	= / -20%
	→	-50%	
	↘	-75% / -100%	

* Recommendations for adjusting basal / intermediate insulin (excluding degludec, see text) and rapid preprandial post-exercise (1-3 hours) in three exercise modes.
**>250 "correction microbolus" (50% individual sensitivity factor)
If glucose >250mg/dL assess "correction microbolus" (50% individual sensitivity factor)(5) Rapid pre-exercise, see text

B. INSULIN PUMP

Adjustments to the basal rate and CH supplements in planned exercise			
CBG/IG 60-90 minutes pre-exercise	**Reduction in BR (temporary) 60-90 minutes before exercise**	**CBG/IG on starting exercise**	**Ingest CH at start of exercise**
<70 mg / dL	50%	<70 mg / dL	10-20 g without bolus
70-150 mg / dL	30-50%	70-150 mg / dL	10-20 g and calculated half
> 150 mg / dL	20-30%	> 150 mg / dL	bolus Not necessary
Adjustments to the basal rate and CH supplements in unplanned exercise			
CBG/IG pre-exercise	**BR reduction (temporary)**	**CBG/IG on starting exercise**	**Ingest CH at start of exercise**
<70 mg / dL	70-80%	<70 mg / dL	20 g without bolus
70-150 mg / dL	50%	70-150 mg / dL	10-20 g without bolus
> 150 mg / dL	30%	> 150 mg / dL	Not necessary

BR: Basal rate; **CBG:** Capillary blood glucose; **IG:** Interstitial glucose; **CH:** Carbohydrates

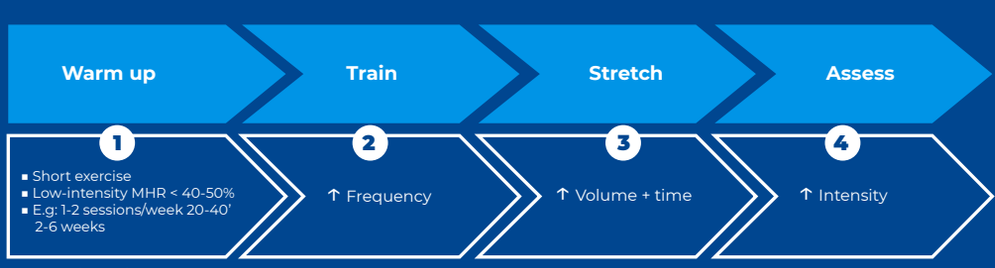
Adjustments in prandial bolus when exercise is planned <2-3 hours later		
Low-moderate intensity aerobic exercise	**Low-moderate intensity anaerobic exercise**	**Intense anaerobic exercise**
Reduce by 25% if low intensity Reduce by 50% to 75% if moderate intensity	May not require adjustment; assess -25 to -50% depending on expected change in glucose based on previous experience	No adjustment required Consider adding small correction with high CBG/IG

C. Non-insulin therapies and physical

Medication	Risk of hypoglycaemia	Considerations on dose adjustment
Sulfonylureas	++	If hypoglycaemia, reduce or stop dose
Glinides	+	If hypoglycaemia, reduce or stop dose
Metformin	-	Not necessary
Pioglitazone	-	Not necessary
Acarbose-Miglitol	-	Not necessary
DPP-4 inhibitors	-	Not necessary
GLP-1 RA	-	Not necessary
SGLT2 inhibitors	-	Stop before intense and prolonged physical exercise (risk of dehydration, hypotension, ketosis/acidosis)

DPP-4 inhibitors: Dipeptidyl peptidase-4; **GLP-1 RA:** glucagon-like peptide-1 receptor agonists; **SGLT2 inhibitor:** Sodium-glucose cotransporter-2 inhibitors

6 TRAINING PLANNING



MHR: Maximum heart rate

7 CHECK LIST

- [ ] **Pre-training medical assessment**
- [ ] **Identification of diabetes**
- [ ] **Diabetes equipment (treatment, monitor/glucometer, glucagon, food, etc.)**
- [ ] **Hypoglycaemia identification and treatment**
- [ ] **Hydration**
- [ ] **Check blood glucose, no exercise if <70 mg/dL/ >270 mg/dL, correct**
- [ ] **No severe hypoglycaemia in previous 6 months**
- [ ] **No acute intercurrent disease**

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INTRODUCTION

Increasing numbers of people are taking up regular exercise which can occasionally be very intense, even if not done professionally. In people with diabetes mellitus (DM), exercise can have a significant impact on metabolic control, requiring specific adjustments to their treatment and diet. In addition, an assessment before doing sport is recommendable, bearing in mind a number of considerations relating to possible comorbidities and the specific type of sport.

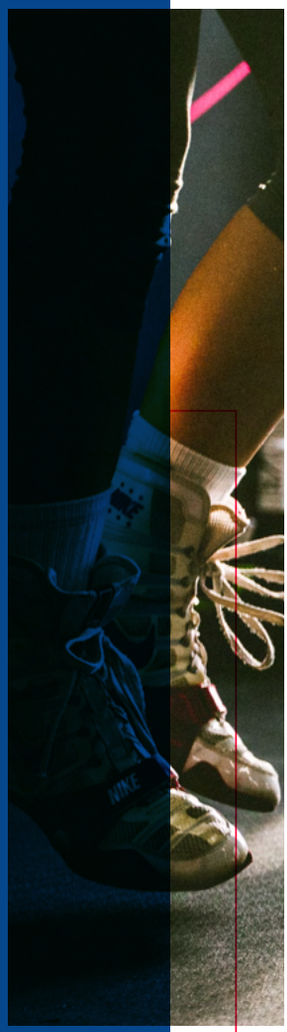
In 2015, the DM Area of the SEEN (DMA-SEEN) drew up the "Clinical recommendations for sport practice in diabetic patients (RECORD Guide)",[1] with the aim of providing guidelines for professionals involved in caring for people with diabetes who play sport.

Today, the appearance of new drugs and blood glucose monitoring systems, the publication of new guidelines and consensuses on the issue and the increasing demand from people with diabetes for guidelines on therapy and control when doing sport has required us to update these recommendations.

METHODS

The DMA-SEEN selected a group of experts in each area covered in the document. The group carried out a literature review of the available evidence on each topic in MEDLINE (Pub-Med) and reviewed articles written in English and Spanish with an inclusion date up to 31 September 2020.

The almost total lack of clinical trials on most of the aspects reviewed meant it was impossible to establish guidelines based on level of evidence so expert guidelines based on available data were drawn up. These final recommendations were discussed jointly by the Working Group and then approved by the SEEN Board of Directors.



1 EFFECTS OF DIFFERENT TYPES OF EXERCISE ON GLYCAEMIC CONTROL

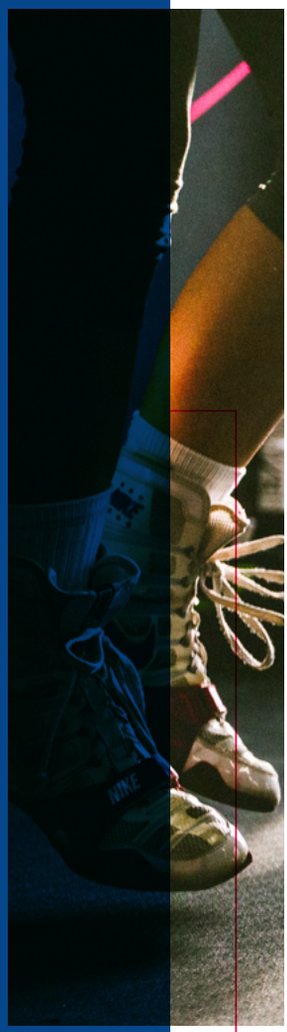
Exercise increases muscle glucose uptake, both improving insulin sensitivity (IS) as independently.[2] The type, intensity, volume and persistence of exercise are factors that influence the benefits in glycaemic control. These effects differ with the type of DM. The intensity of aerobic exercise is technically defined in terms of muscle O2 consumption, while a more general definition normally uses percentage of maximum heart rate (%MHR): intensity is mild if %MHR is <40-50%, moderate between 50-70% and high if >70-80%.

Type 2 diabetes mellitus (T2D)[2]:

- Both aerobic and resistance exercise temporarily improve IS by around 20%. The effect disappears after 48-72 h.
- Performed on a regular basis, both types of training further increase IS (>40%), improving HbA1c levels by 0.4-0.5%.
- Combining both types of exercise, aerobic and resistance, improves these results, increasing IS by around 70% and reducing HbA1c by 0.9%.
- The improvement in IS and drop in HbA1c depend on the intensity of the exercise. The higher the intensity, the greater the benefit.
- A training plan based on high-intensity interval training (HIIT) provides similar benefits to continuous, moderate-intensity aerobic exercise, while reducing the time required by 40% (1.5 vs. 2.5 h/week) and the training volumen.

Type 1 diabetes mellitus (T1D):

- Evidence in T1D is more limited and controversial than in T2D people[3-10].
- The short-term effect on plasma glycaemia depends on the type of exercise, circulating insulin levels, previous blood glucose and intake, as well as stress associated with the sport[3-5]:
  - Prolonged, moderate-intensity aerobic exercise is associated with a



significant drop in glucose in people with optimum insulin levels. This drop leads to a higher risk of hypoglycaemia during or after exercise[5,6].

- High-intensity sport in conditions of insufficient insulin levels and pre-exercise stress increases the risk of hyperglycaemia and ketosis[6,7].

- In terms of HbA1c, cross-sectional studies suggest that greater physical activity is associated with better glycaemic control. However, it cannot be concluded from the results of clinical trials that doing regular exercise significantly improves HbA1c in adults with T1D[3,5-7].
- In paediatric T1D, regular exercise improves HbA1c by 0.3%[3].
- In a recent study in overweight or obese adults, the practice of HIIT for 12 weeks was associated with a significant decrease in HbA1c, compared to the control group (-0.64% vs -0.14%, p=0.04), only in those with an adherence ≥ 50% to the training plan.[8].
- Exercise has demonstrated a number of other important health benefits for people with TID, as well as a decrease in insulin requirements, thus it should be used as an essential part of the education programme.[9].

RECOMMENDATIONS 1

- **Type 2 diabetes mellitus:**
  1. Both aerobic and resistance exercise improve IS and HbA1c. These benefits are enhanced by a combination of both, as well as by increased intensity and regularity of exercise
  2. A HIIT-based training plan provides similar benefits, but with a significant time savings.
- **Type 1 diabetes mellitus:**
  1. The short-term effect on blood glucose depends mainly on insulin levels and the type of exercise.
  2. There is insufficient evidence to conclude that regular exercise consistently improves HbA1c levels in adults with T1D. Nevertheless, it should be recommended.
  3. In overweight or obese people, HIIT-based exercise programmes improve HbA1c levels when adherence is adequate.

2 MEDICAL ASSESSMENT BEFORE EXERCISE

Several scientific societies recommend that patients with diabetes undergo a medical assessment before starting an exercise programme.[10,11,12] Medical approval is not necessary in asymptomatic people receiving diabetic care who wish to start low to moderate-intensity physical activity.[13] However, people who plan to do more demanding sport or who have more risk factors (age, diabetes for over 10 years, cardiovascular disease, among others) may benefit from additional testing.[3] This assessment should include the following points:

Set targets

- Determine whether there is any disease or complication that might appear or worsen with exercise.
- Plan and schedule exercise and performance-related options.
- Prevent musculoskeletal injuries.

Diabetes care plan

Each athlete with diabetes should have a diabetes care plan that includes the following[14]:

- Blood glucose control. Frequency of monitoring and contraindication figures for exercise.
- Insulin therapy. Type of insulin, dose and adjustment strategies for the type of activities planned.
- Recommendations for recognising and treating hypoglycaemia, including instructions for use of glucagon.
- Contact information in case of emergency (contact phone numbers).
- Identification of the presence and type of diabetes (medical alert).
- Adequate recommendations regarding food and hydration needs.

Pre-exercise medical examination

A physician should determine any limitations or restrictions to doing exercise for athletes with diabetes-related complications.

- Athletes with diabetes should take an HBA1c test every 3 to 4 months.

People with diabetes and possible cardiovascular disease (CVD) or diabetic microvascular complications wishing to do some form of sport should undergo a medical assessment. This should include: history, physical examination (including metadiabetic complications), resting electrocardiogram (EKG) and, possibly, a stress test.[15]

The assessment should be repeated every 3-5 years with a resting ECG;[10] depending on the ECG findings, the assessment should be extended to the other tests (such as a stress ECG or echocardiogram). Of course, successive specific studies also must be performed when signs and/or symptoms of possible CV disease appear.

Formulation of specific recommendations (Table 1)

Table 1: Exercise and complications of diabetes

Complicación	Recomendaciones	Contraindicaciones	Precauciones
Enfermedad cardiovascular	Actividades aeróbicas de bajo impacto: caminar, bicicleta, natación, cinta	IAM reciente (<6 semanas). Actividades hipertensivas: levantar pesos importantes, elevada intensidad	Incrementar la frecuencia cardíaca gradualmente
Neuropatía autonómica	Ejercicios poco intensos y que no modifiquen la presión arterial: actividades acuáticas, bicicleta estática y ejercicios sentado	Elevada intensidad. Cambios bruscos de la posición corporal	Test para detectar la presencia de enfermedad coronaria. Mantener la PA para evitar ortostatismo. Evitar hacer ejercicio en ambientes muy fríos o muy calurosos y mantener hidratación adecuada. Monitorizar la glucemia
Neuropatía periférica	Natación, ciclismo, ejercicios de silla, ejercicios de brazos y aquellos que no requieran la utilización de los pies	Caminatas prolongadas muy exigentes, correr, cualquier actividad que conlleve saltar. No realizar ejercicio si existen úlceras o pie de Charcot activo	Evaluación preejercicio de la sensibilidad. Calzado adecuado. Revisión de higiene diaria de los pies
Retinopatía diabética	Ejercicios aeróbicos de baja intensidad: bicicleta estática, caminar, natación, cinta rodante	No realizar actividad física en presencia de RP activa (hemorragia vítrea, tracción fibrosa) y tras fotocoagulación o cirugía recientes. Evitar ejercicios que aumenten la PA bruscamente (actividades físicas violentas, Valsalva, pesos), aquellos que conlleven movimientos bruscos o de bajar la cabeza (gimnasia, yoga) y de contacto (boxeo, artes marciales, etc.)	Aumento gradual en la intensidad. Evitar durante el ejercicio PA sistólica >170 mmHg
Nefropatía diabética	Actividades aeróbicas de baja intensidad	Evitar ejercicios que aumenten la PA bruscamente: actividades físicas violentas, Valsalva, levantar pesos	Particular énfasis en la hidratación y control de la PA

IAM: infarto agudo de miocardio; **PA:** presión arterial; **RP:** retinopatía proliferativa

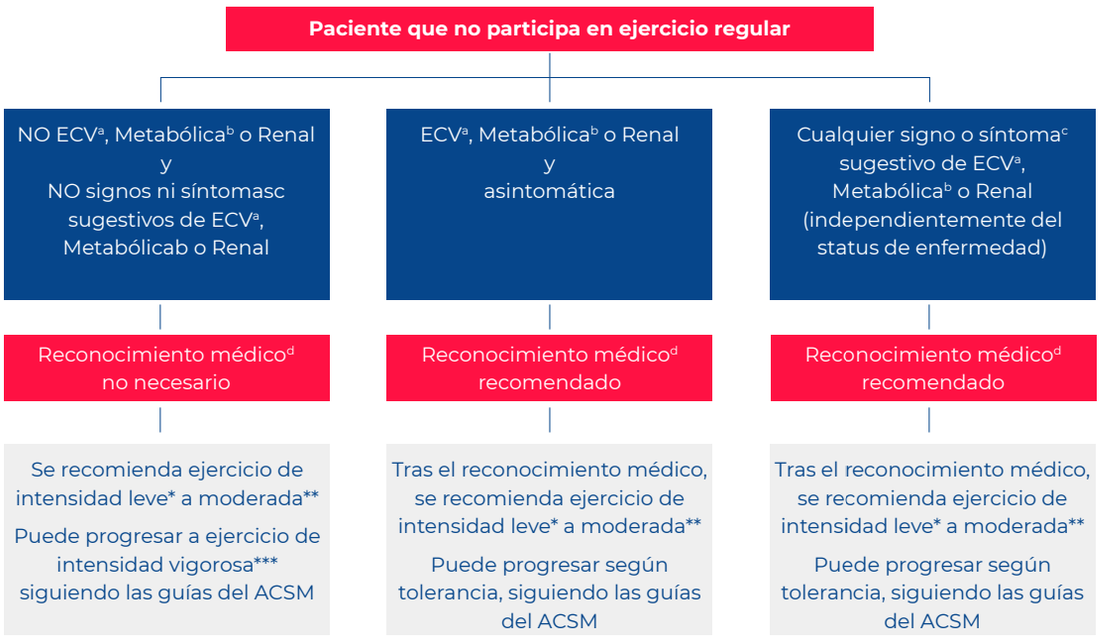
The following are considered absolute contraindications for sport in people with diabetes: poor glycaemic control and, in severe retinopathy, avoid exercise that clearly increases intraocular pressure and thus the risk of vitreous haemorrhage and detached retina. All other contraindications are relative.
Cardiovascular disease. Routine screening for coronary heart disease in people

with asymptomatic diabetes remains controversial. The American Diabetes Association (ADA) does not recommend it,[12] except in people with high-risk diabetes[16] (Table 2), where a stress test before a moderate to high-intensity exercise programme would be used.[17] People with diabetes and established coronary heart disease, even with no significant ischaemia or arrhythmias, should generally not do high-intensity exercise (reaching 60% to 80% MHR). For people with angina, the target heart rate should be at least 10 beats below the ischaemic threshold.[17] Figure 1 shows the American College of Sports Medicine algorithm to identify patients at risk of CV complications[18] and Figure 2 shows the steps to follow for people with diabetes who have been referred for a cardiopulmonary exercise test.[19] There are little data on the risk of CV complications during strength or resistance training to justify recommendations, but it seems to be low. However, it is important to identify the intensity at which a person wants to do exercise.

Table 2: Patients at risk for whom pre-exercise assessment is recommended

- Edad mayor de 35 años
- Edad mayor de 25 años y DM2 diagnosticada hace más de 10 años
- Edad mayor de 25 años y DM1 diagnosticada hace más de 15 años
- Presencia de otros factores de riesgo de enfermedad cardiovascular
- Existencia de complicaciones microvasculares: retinopatía, nefropatía
- Enfermedad vascular periférica
- Neuropatía autonómica

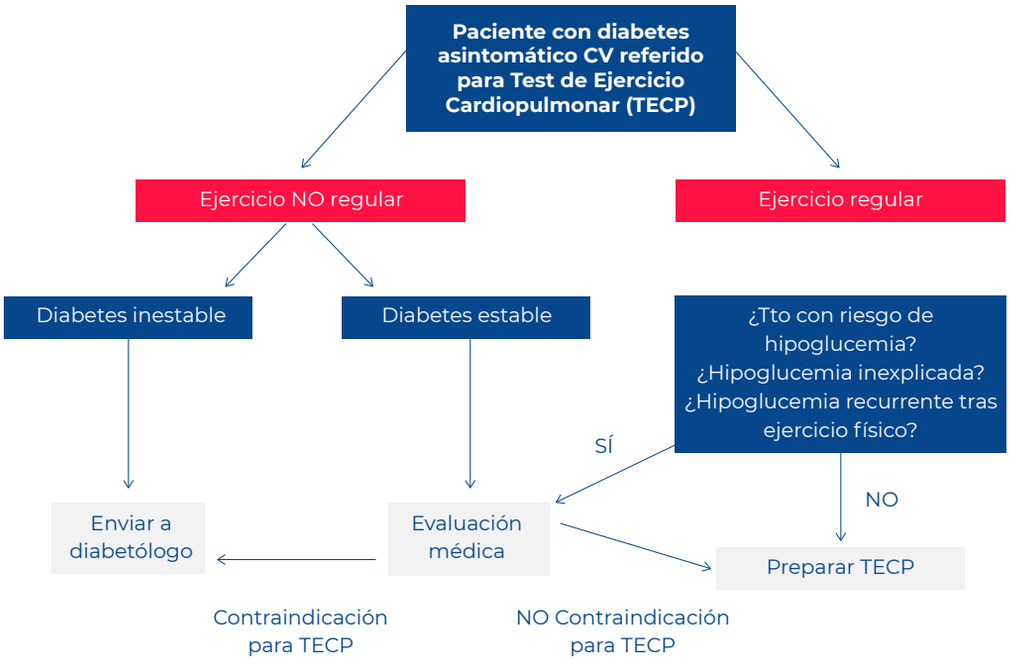
Figure 1: Identification of patients at risk of CV complications



a: ECV: cardíaca, vascular periférica o cerebrovascular; b: Enfermedad metabólica: diabetes mellitus tipo 1 y 2; c: Signos y síntomas: en reposo o durante actividad. Incluye dolor, disconfort en el pecho, cuello, mandíbula, brazos, u otras áreas que pueden afectarse por isquemia; falta de aire en reposo o con ejercicio leve; mareo o síncope; ortopnea o disnea paroxística nocturna; edema de tobillos; palpitaciones o taquicardia; claudicación intermitente; soplo cardíaco; astenia inusual o falta de aire con actividades habituales; d: aprobación de un profesional sanitario para realizar ejercicio; * Se considera ejercicio de intensidad ligera aquel que supone un 30-39% de la frecuencia cardíaca de reserva o VO2R, 2-2,9 METS, índice de esfuerzo percibido 9-11, una intensidad que ocasiona un ligero aumento de la frecuencia cardíaca y respiratoria; ** Se considera ejercicio de intensidad moderada aquel que supone un 40-59% de la frecuencia cardíaca de reserva o VO2R, 3-5,9 METS, índice de esfuerzo percibido 12-13, una intensidad que ocasiona un aumento notable de la frecuencia cardíaca y respiratoria; *** Se considera ejercicio vigoroso aquel que supone ≥ 60% de la frecuencia cardíaca de reserva, ≥ 6 METS, índice de esfuerzo percibido ≥ 14, una intensidad que ocasiona un aumento sustancial de la frecuencia cardíaca y respiratoria.

Modificado de: American College of Sports Medicine. Riebe D, Ehrman JK, Liguori G, & Magal M (2018). ACSM's guidelines for exercise testing and prescription (Tenth edition). Philadelphia: Wolters Kluwer

Figure 2: Detecting and preparing people with diabetes for cardiopulmonary exercise testing



TECP: Test de Ejercicio CardioPulmonar

Modificado de: Front Physiol 2019;10:1257-1263

Autonomic neuropathy. People with diabetes and autonomic neuropathy should undergo a prior stress test before starting an exercise programme. Autonomic neuropathy alters thermoregulation, so precaution should be taken with exercise in hot or cold atmospheres. With gastroparesis, carbohydrate absorption can be delayed, possibly causing a predisposition to hypoglycaemia. Athletes with autonomic neuropathy should use perceived exertion instead of heart rate response to control exercise intensity.

Peripheral neuropathy. Special attention should be paid to all aspects of the lower extremities: abnormal pressure areas, wounds, ulcers, deformities, etc. (all of which are risk factors for developing diabetic foot).

Diabetic retinopathy. All activities that increase intraocular pressure should be avoided, due to the risk of vitreous haemorrhage or detached retina. Limit the rise in systolic blood pressure to no more than 20 to 30 mmHg above the basal rate during each training session.

Diabetic nephropathy. Presence of microalbuminuria does not require restrictions to exercise. In more advanced phases, avoid activities that increase systolic blood pressure over 180-200 mmHG and may cause progression in the disease. In more developed stages of kidney disease, only lower-intensity physical activity should be done (around 50% of maximum VO2) as, cardiorespiratory and health benefits have been observed at this level of exercise.

Special examinations

Stress test: What is it for?

- Prescribing exercise. The intensity of exercise can be prescribed and assessed more precisely using %MHR than with estimated target heart rate or work rate from calculations based on based on age. In addition, in cases where ischaemia or arrhythmias are induced at higher exercise intensities, the results of stress testing can be used to keep intensity below the ischaemic threshold.

- Determining risk stratification, bearing in mind that low aerobic capacity and presence of ischaemic changes in the ECG are both associated with a higher risk of cardiovascular and overall morbidity and mortality.

- Detecting silent coronary heart disease.

- Detecting abnormal hypertensive responses and thus prevent them by recommending appropriate physical activities.

Baseline spirometry

This is recommended systematically for all athletes, as restrictive patterns of 20% compared to reference values require a study of airway hyper-responsiveness to exercise. In such cases, a stress test with gas analysis will be carried out, with pre- and post-exercise spirometry at 5, 10 and 20 minutes, assessing whether restriction to ventilatory parameters increases. If positive, a further test with bronchodilators will be required to determine the degree of disease and the diagnostic orientation.

Resting electrocardiogram

Assessing:

- Heart rate and PR, QRS and QT intervals.
- The P-wave morphology of the QRS complex and the T-wave.
- Determination of the cardiac axis.

Electrocardiographic abnormalities, rhythm control, blockages and ischaemic lesions that contraindicate undergoing a stress test.

Assessment of exercise habit and risk of hypoglycaemia

In accordance with recommendations by the European Association for the Study of Diabetes (EASD) and the International Society for Pediatric and Adolescent Diabetes (ISPAD) [20], people with diabetes who intend to do sport should be classified by their exercise habit (EH) as:

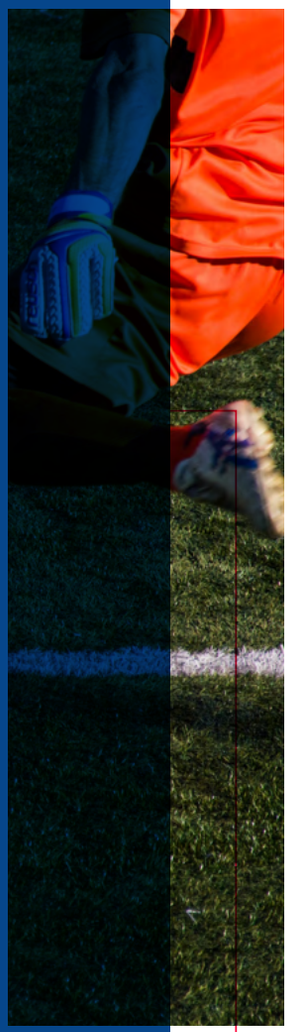
- Intense EH: >2 exercise sessions a week lasting ≥ 45 minutes.
- Moderate EH: 1-2 exercise sessions a week lasting ≥ 45 minutes.
- Low EH: no regular exercise.

They should also be classified by risk of hypoglycaemia, when they have interstitial glucose monitoring (IGM), depending on time below range (TBR) less than 70 mg/dL, in:

- Low-risk hypoglycaemia: conserved recognition of hypoglycaemia and TBR <4% in the last three months.
- Moderate-risk hypoglycaemia: conserved recognition of hypoglycaemias and TBR 4-8% in the last three months.
- High-risk hypoglycaemia: unnoticed or severe hypoglycaemia in the last 6 months and/or TBR >8% in the last 3 months.

RECOMMENDATION 2

1. People with diabetes with possible CV disease or microvascular complications who wish to do exercise substantially more vigorous than light walking should undergo a medical assessment, which should include history, physical examination (including eye fundus examination, foot examination and neuropathy detection), resting ECG and, possibly, stress testing.
2. Stress testing should be carried out on all patients considered high risk for CV disease.
3. Stress testing has multiple uses:
   - Prescribing exercise.
   - Determining risk stratification.
   - Detecting silent coronary heart disease.
   - Detecting abnormal hypertensive responses.
4. It is recommendable to classify people by the exercise habit and risk of hypoglycaemia.



3 CHANGES TO DIET

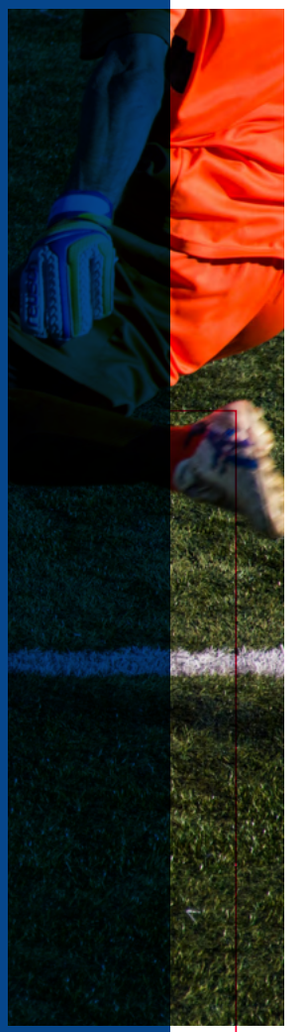
Macronutrient intake

There is no single, ideal macronutrient distribution for athletes with diabetes,[12] hence it needs to be tailored to the individual. Predictive equations for energy expenditure and body composition data are useful for calculating macronutrient requirements. The recommended macronutrient balance is 45-65% carbohydrates (CH), 20-35% fats and 10-35% proteins (Table 3).[5] The amount of CH depends on the intensity and duration of the habitual training.[21,22] The benefits of a CH loading, 8-12 g/kg/day (70-85% daily calorie intake) three days before competition has been shown to delay glycogen depletion in events longer than 90 minutes in T1D, but not in T2D[23] .
Although the metabolic and performance-related benefit of low-CH diets (<140 g CH/day) in athletes has been described, there is little current evidence for it in athletes with diabetes[24]. Such diets should be supervised and accompanied by a period of adaptation due to a greater risk of ketoacidosis, hypoglycaemia, lipid alterations, micronutrient deficiency and glycogen depletion[9].

Table 3: Recommended daily intake of macronutrients in athletes with diabetes

MACRONUTRIENTES	**Hidratos de carbono**	3-5 horas de ejercicio/semana → 4-5 g HC/kg/día 5—10 horas ejercicio/semana → 5-7 g HC/kg/día 10-15 horas ejercicio/semana → 7-8 g HC kg /día >15 horas ejercicio/semana → 8-10 g HC/ kg/día En ejercicios extremos / competición puede ser necesario 12 g HC/kg/día Priorizar alimentos de bajo IG No evidencia actual del beneficio de las dietas muy bajas en HC (< 140 g/día) para el deportista con DM1
	Proteínas	1,2 – 1,6 g/kg/día (Priorizar proteínas de alto valor biológico; mayor aporte en deportes de fuerza y ejercicio aeróbico de larga duración)
	Grasas	20-35% volumen calórico total (Un aporte ≤ 20% de grasas no supone beneficios)

IG: Índice Glucémico; **HC:** Hidratos de Carbono



Micronutrient intake

It is advisable to ensure vitamin B group intake. Vitamin B12 deficiency, which is frequent with metformin, reduces performance, but can be improved with supplementation[22]. Hyperglycaemia may be associated with hypomagnesemia,[25] which in turn causes muscle cramp. This can be reduced through replacement.[22] Other micronutrients essential to athletes with diabetes are iron, calcium and vitamin D. Deficient diets can lead to excessive sodium and potassium-poor diets which, together with hypomagnesemia, cause high blood pressure.[26] Preliminary data suggest a potential benefit of vitamin C supplementation in reducing blood pressure and oxidation markers while improving diastolic function in T2D. Supplementation should only be used when there is dietary or demonstrated deficiency.

Intake during physical exercise

This is summarised **in Tables 4 to 7.** [5,9,20,22]. Supplement with CH if pre-exercise blood glucose is below 100 mg/dL.[12,27] Tailor according to individual tolerance to CH, as excessive amounts can produce digestive discomfort. It is estimated that an average of 36 g of CH/hour is required to prevent hypoglycaemia in athletes with T1D who have had a bolus injection in the 2 hours prior to moderate-intensity aerobic exercise.[20]

In T1D, fasted training in the morning requires supplementing with a smaller amount of CH, due to lower insulin and high cortisol and GH levels, as hypoglycaemia is less frequent compared to other times of day[28] (except with high-intensity exercise or HIIT).

Preliminary data support consumption of slow-burning CH (SRCH) 2 hours before a high-intensity race in T1D compared to a high glycaemic index (GI) supplement due to improved glycaemic response.[29,30] During prolonged exercise or recovery, SRCH reduce the risk of hypoglycaemia and prevent hyperglycaemic peaks.[30,31]

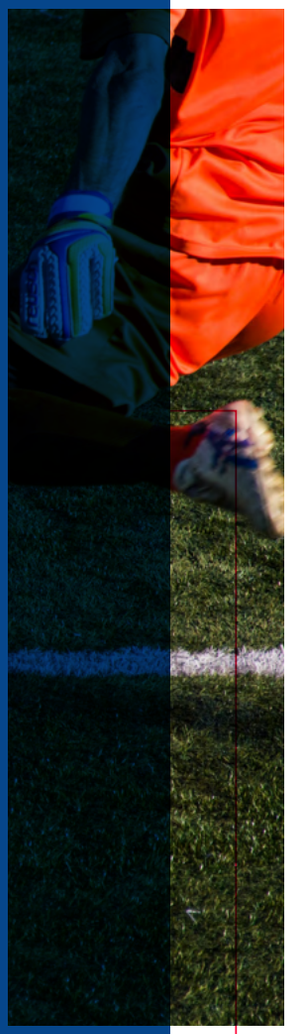


Table 4: Pre-exercise supplementation in T1D without glucose monitoring or in T2D treated with basal insulin and/or secretogogues.

	Suplementación de HC Niveles orientativos, ajustar en cada caso	
	Niveles basales de insulina (DM1/ DM2 bolus administrado hace más de 2 horas; DM2 en tratamiento con secretagogos)	Niveles elevados de insulina (DM1/ DM2 bolus previo en últimas 2 horas)
Ejercicio de hasta 30 minutos	Si glucemia < 90 mg/dL, ingerir 10-20 g GL	15-30 g GL para prevenir/tratar hipoglucemia
Ejercicio 30-60 minutos	Intensidad baja-moderada (aeróbico): 10-15 g GL/h Intensidad alta (anaeróbico): no suplementar salvo glucemia < 90 mg/dL con 10-20 g GL	15-30 g GL / 30 minutos para prevenir hipoglucemia
Ejercicio 60-150 minutos	30-60 g GL/hora	Hasta 75 g GL/hora
Ejercicio > 150 minutos	60-90 g GL+ HCL /hora, ajustar insulina si precisa	60-90 g GL+ HCL /hora, ajustar insulina si precisa

GL: glucosa/hidratos de carbono de absorción rápida; **HCL:** hidratos de carbono de absorción lenta

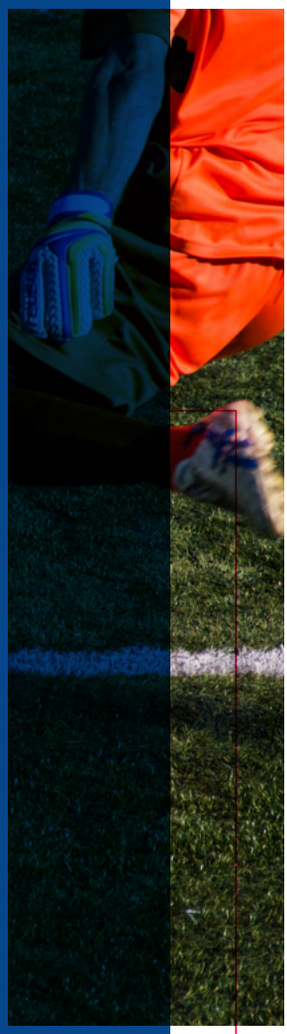


Table 5: CH supplementation before sport in T1D with glucose monitoring

Glucemia pre ejercicio			Flecha de tendencia	Acción	
HD intenso y/o bajo riesgo hipoglucemia	HD moderado y/o Riesgo moderado de hipoglucemia[i]	HD bajo y/o alto riesgo de hipoglucemia[ii]	Dirección	Se espera aumento de la glucemia	Se espera descenso de la glucemia
126-180 mg/dL	145-198 mg/dL	162-216 mg/dL	↗ ↑ →	Iniciar ejercicio	Iniciar ejercicio
			↘ ↓	Iniciar ejercicio	Iniciar ejercicio +15 g GL
90-125 mg/dL	90-144 mg/dL	90-161 mg/dL	↗ ↑	Iniciar ejercicio	Iniciar ejercicio +15 g GL
			→	Iniciar ejercicio +10 g GL	Iniciar ejercicio +20 g GL
			↘	Demorar ejercicio[iii] + 15 g GL	Demorar ejercicio[iii] +25 g GL
			↓	Demorar ejercicio[iii] + 20 g GL	Demorar ejercicio[iii] +30 g GL
70-89 mg/dL			↑	Iniciar ejercicio +10 g GL	Demorar ejercicio[iii] +20 g GL
			↗	Demorar ejercicio[iv] +15 g GL	Demorar ejercicio[iii] +25 g GL
			→	Demorar ejercicio[iv] +20 g GL	Demorar ejercicio[iii] +30 g GL
			↘	Demorar ejercicio[iv] +25 g GL	Demorar ejercicio[iii] +35 g GL
			↓	Demorar ejercicio[iv] + GL personalizada	Demorar ejercicio[iii] +GL personalizada
< 70 mg/dL			Demorar ejercicio[v] + GL personalizada		

i. incluye ancianos con status funcional y funciones superiores conservadas
ii. incluye ancianos con alteración ≥2 actividades instrumentales vida diaria o deterioro cognitivo leve-moderado)
iii. demorar ejercicio hasta tener al menos 90 mg/dL y flecha de tendencia ↗,↑ó →
iv. demorar ejercicio hasta tener al menos 70-89 mg/dL y flecha de tendencia ↑
v. demorar ejercicio hasta tener al menos 70-89 mg/dL y flecha de tendencia ↑ si se espera aumento de la glucemia durante el ejercicio o demorar ejercicio hasta alcanzar 90 mg/dL y ↗,↑ ó → si se espera descenso de la glucemia durante el ejercicio

GL: glucosa/hidratos de carbono de absorción rápida; **HC:** hidratos de carbono; **HD:** hábito deportivo

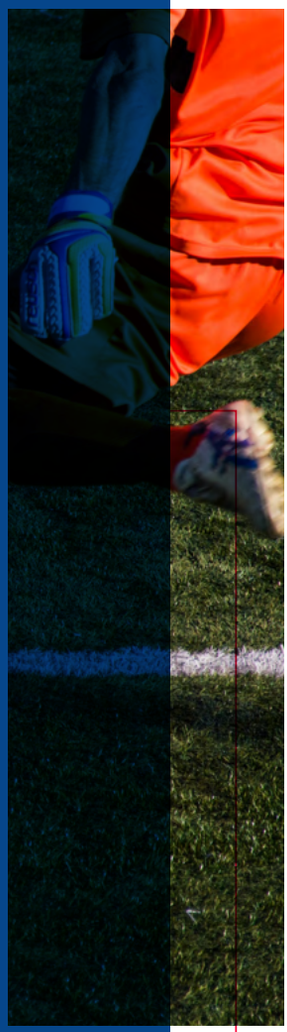


Table 6: CH supplementation during sport in T1D with glucose monitoring

Glucemia durante ejercicio			Flecha de tendencia	Acción	
HD intenso y/o bajo riesgo hipoglucemia	HD moderado y/o Riesgo moderado de hipoglucemia[i]	HD bajo y/o alto riesgo de hipoglucemia[ii]	Dirección	Se espera aumento de la glucemia	Se espera descenso de la glucemia
< 126 mg/dL	< 145 mg/dL	< 162 mg/dL	↗ ↑	Continuar ejercicio	Continuar ejercicio
			→	Continuar ejercicio[iii] +10 g GL	Continuar ejercicio[iii] +15 g GL
			↘	Continuar ejercicio[iii] +15 g GL	Continuar ejercicio[iii] +25 g GL
			↓	Continuar ejercicio[iii] +20 g GL	Continuar ejercicio[iii] +35 g GL
< 70 mg/dL			Cualquier tendencia	Reposición GL personalizada	

i. incluye ancianos con status funcional y funciones superiores conservadas
ii. incluye ancianos con alteración ≥2 actividades instrumentales vida diaria o deterioro cognitivo leve-moderado)
iii. comprobar el sensor al menos 30 minutos tras la ingesta de GL y repetir ingesta GL si es necesario

GL: glucosa/hidratos de carbono de absorción rápida; **HC:** hidratos de carbono

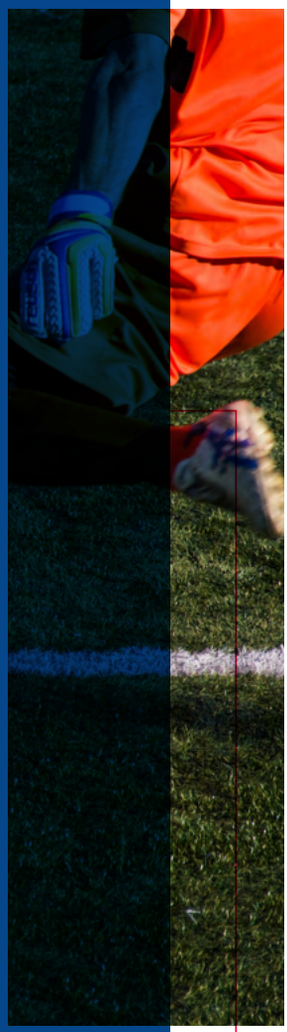
Table 7: CH supplementation after sport in T1D with glucose monitoring

Glucemia post ejercicio/antes de dormir si ejercicio practicado a última hora de la tarde			Flecha de tendencia	Acción
HD intenso y/o bajo riesgo hipoglucemia	HD moderado y/o Riesgo moderado de hipoglucemia[i]	HD bajo y/o alto riesgo de hipoglucemia[ii]	Dirección	Suplemento de GL[i]
< 80 mg/dL	< 90 mg/dL	< 100 mg/dL	↗ ↑	No
			→	+10 g GL
			↘	+15 g GL
			↓	Aporte individualizado

i. comprobar glucemia a los 30 minutos, repetir administración GL si es necesario

Hydration

People with diabetes are more likely to dehydrate during exercise[22]. The drink of choice is water. In exercise lasting over 1 hour, isotonic drinks can prevent hypoglycaemia and help replace electrolytes[32]. Ensure a water intake of 1 L/hour, although requirements may be higher depending on circumstances.



Recovery after exercise

After finishing the exercise, if blood glucose is less than 120 mg/dL, ingesting 15-20 g SCH is recommended for both T1D and T2D treated with insulin or secretagogues[27]. If IGM is available, follow indications in Table 7[20].
Competing athletes should ensure glycogen replacement, taking 1-1.5 g CH/kg in the first 2 hours post-exercise[22]. Monitor hyperglycaemia associated with explosive exercise[5,9]. If post-exercise CH intake is insufficient, taking it with proteins may be beneficial[22,7]. After strenuous or prolonged exercise, a night-time snack with fat, CH and protein can prevent nocturnal hypoglycaemia[33].

Products available on the market

Isotonic drinks are useful in exercise lasting longer than 60 minutes[5,9]. Avoid soft drinks and energy drinks. Milk drinks are useful for recovery from and prevention of late hypoglycaemia[34]. Glucose gels or tablets, energy bars and powdered CH concentrates can also be used. **See Tables 8 and 9**

Table 8: Examples of food by CH content

Ejemplos alimentos según aporte de HC		
15 g HC (1,5 raciones HC)	**60 gr (6 raciones HC)**	**HC absorción lenta**
250 mL bebida isotónica (un vaso)) (leer etiquetado)	1 L de bebida isotónica (cuatro vasos) (leer etiquetado)	Barritas energéticas de cereales
4 galletas tipo maría	16 galletas tipo maría	Copos de avena con leche entera
1 brick de zumo pequeño	6 gallegas tipo príncipe	Bocadillo de pan blanco tipo vegetal
30 g de pan blanco	8 galletas tipo digestiva	Pan integral
Una rebanada de pan de molde	4 rebanadas de pan de molde	Frutas: aguacate, chirimoya, granada, manzana, melocotón, piña, pera, níspero, nectarina, ...
Una manzana pequeña	120 g de pan blanco (unos 12 cm de longitud)	Verduras cortadas, cantidad que aporta una ración HC, ejemplos: 150 g zanahoria no cocida, 300 g berenjena, 300 g pepino, 300 g calabacín. Pueden combinarse con hummus de garbanzos, 100 gramos aportan 1 ración HC aprox
Medio plátano	3 naranjas medianas	Frutos secos: almendra, nuez, pistachos, pipas,...
Medio vaso de bebida refrescante tipo cola o sabores	3 peras medianas	Bebida de soja
Un sobre de gel de glucosa Pastillas de glucosa	3 plátanos pequeños	Barritas energéticas low-carb (leer etiquetado
Una barrita energética de cereales (leer etiquetado).	Dos vasos de horchata	
Bolsa pequeña (30 g) de patatas chip	5 puñados con la mano cerrada de uvas pasas	
Un tercio de cerveza sin alcohol	Cuatro barritas energéticas de cereales (leer etiquetado).	

HC: hidratos de carbono

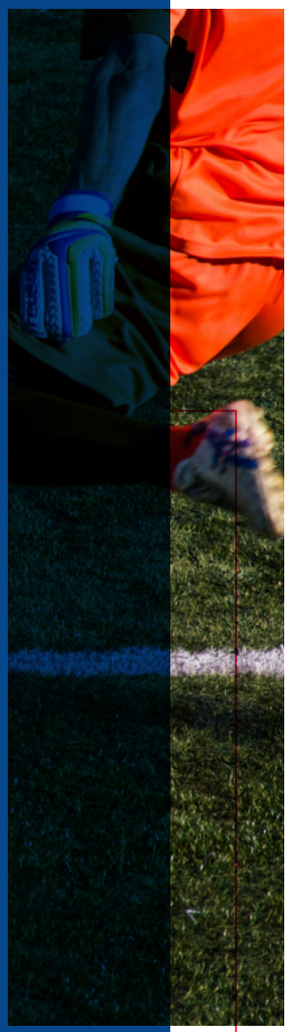


Table 9: Composition of supplements most commonly used in sport.

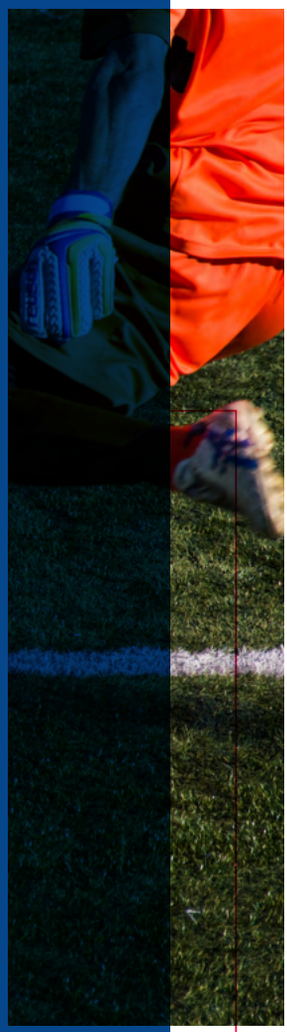
Bebidas isotónicas: 5-8% azúcares + iones (sodio 10-35 mmol/L; potasio 3-5 mmol/L; osmolaridad 270-330 mOsm/L).		
	HC (g/100 mL)	Na (g/100 mL)
Gatorade®	5,8g	0,13g
Powerade®	5 g	0,13g
Aquarius®	4,4 g	0,05 g
UpGrade®	4,9g	0,08 g
Etixx®	5,1g	0,12g
Bebidas isotónicas en polvo para reconstituir , consultar composición nutricional		
Geles de glucosa (revisar etiquetado, buscar procedencias fiables)		
Diabalance®	15 g HC por sobre/ 5g por sobre5,8g	1, 8 euros por sobre
Gluc Up®	15 g HC por sobre	1,6 euros por sobre
Comprimidos de glucosa		
Glucosport®	5 gramos HC por comprimido	0,20 euros por comprimido
Barritas para deportistas (revisar etiquetado, buscar procedencias fiables).		
Mezcla HC: 40-50 g; proteínas 5-10 g; incluyen también vitaminas y minerales; suelen ser bajas en grasa y fibra		
Concentrado de hidratos de carbono en polvo (revisar etiquetado, buscar procedencia fiable)		
Deben contener al menos 75% HC y de éstos, las ¾ partes ser HC de alto índice glucémico (por ejemplo, glucosa y sacarosa).		

Performance enhancers

Evidence in people with diabetes is limited[5,9,22]. Chrome, vanadium and zinc supplements may improve insulin sensitivity. The advice of the Spanish Society of Sport Medicine[34] may be applicable to athletes with diabetes. Bear in mind that some supplementation regimens, such as with creatine, include adding CH, so adjustments may have to be made to treatment. Taking 5 mg/kg of caffeine pre-exercise (an espresso coffee) in T1D reduces hypoglycaemia during exercise but can increase late hypoglycaemia[36,37].

Other aspects

People with T1D are at greater risk of developing eating disorders[20], and attention should be paid to warning data.
Physical exercise can mask the symptoms of hypoglycaemia. Algorithms such



as the Exercise Carbohydrates Requirement Estimating Software (ECRES) predictive model[38–40] for blood glucose levels according to the athlete's characteristics have been proposed to help in decision-making.

RECOMMENDATIONS 3

1. There is no ideal recommendation concerning macronutrients. The recommended macronutrient requirement is 45-65% CH, 20-35% fats and 10-35% proteins.
2. Patients who are on insulin or secretagogues should have their capillary blood glucose checked before exercising. If less than 100 mg/dl, a supplement containing CHs should be taken.
3. It is important to maintain an adequate state of hydration during exercise. For longer than 1 hour, a total of 30-60 g CH per hour should be ingested.
4. After exercise, CH replacement should be ensured, preferably with low-GI CH.

4 GLUCOSE MONITORING

Interstitial glucose monitoring (IGM) systems are a useful tool with the potential to provide significant help in maintaining glucose levels in the target range while doing physical exercise, although with limitations[41,42]. Their use has been questioned because the sensor requires 10-15 minutes to balance interstitial glucose (IG) and capillary blood glucose (CBG) values, possibly longer in situations of rapidly changing glucose concentrations, such as to asess the both aerobic and anaerobic exercise.[1] Use of the IGM has also helped assess the effect of different types of exercise on glucose values and the counterregulatory response to exercise,[43] thus these devices could be used as an educational tool for people with diabetes, permitting the insulin dose and CH intake to be modified[44].

With regard to **continuous glucose monitoring** (CGM), most studies have been conducted in patients with sedentary behaviour, however there are an increasing number of studies that assess the reliability and precision of the sensors during exercise. Different studies have shown the reliability of different sensors (Guardian®-RT, Guardian®-REAL and the Guardian-TM G3 by Medtronic) while doing high-intensity exercise among people with T1D.[45-50] There are even studies, on few patients, that show the usefulness and reliability of CGM in adventure sports such as diving,[51] where the inability to measure CBG is a risk, and there are even guidelines to support its use as adjuvant therapy[52].

Flash glucose monitoring (FGM) might also be a useful tool when doing exercise.[53] However, the reliability of the data would not be completely accurate at low glucose values and during exercise, where CBG checks would be more recommendable.[54] In addition, a study using the Freestyle Libre® found that use of FGM in people with T2D could encourage physical activity[55].

The joint **position** of the EASD, ISPAD and ADA on the use of CGM and FGM for exercise[20] suggests the following adjustments during exercise:

- Preparation prior to exercise:
  - It is recommendable to set the hypoglycaemia alarm on the CGM or FGM system at the highest permitted level (currently 100 mg/dL) during peak exercise.
  - It is recommendable to set the hyperglycaemia alarm to over 180 md/dL in order to avoid alarm fatigue.

- During exercise:
  - In general, a time in range (TIR) of 90-180 mg/dL (between 126-180 mg/dL in the case of prolonged aerobic exercise) is recommendable for most adults with T1D, while a slightly higher is suitable for people with diabetes and high risk of hypoglycaemia.

- After exercise:
  - A TIR of between 80-180 mg/dL is recommendable for the first 90 minutes after doing exercise for most people with T1D and at low risk of hypoglycaemia.
  - A CGM or scan check every 15-30 minutes for the first 90 minutes after exercise is recommendable.
  - It is recommendable to modify the hypoglycaemia alarm to 80, 90 or 100 mg/dL depending on the risk of mild, moderate or severe hypoglycaemia.

RECOMMENDATIONS 4

1. Use of continuous and flash glucose meters *provides therapeutic* support when doing exercise
2. It is recommendable to analyse the sensor data during and after physical activity to:
   - Modify the insulin dose
   - Adapt CH intake
   - Minimise late hypoglycaemia
3. If hypoglycaemia is detected in interstitial blood during exercise, capillary blood should be checked
4. The *manufacturer's recommendations for use should be followed*: temperature, water resistance, etc.
5. There are no conclusive data on height, depth or contact sport, although it seems they may be useful in exercises such as underwater diving and high-altitude sports.

5 INSULIN THERAPY STRATEGY

The most frequently used insulin therapy is multiple subcutaneous injections.

Options for adapting its action profile to physical activity (especially unplanned) are more limited than with continuous subcutaneous insulin infusion (pumps) use. However, some recommendations, which can always be tailored to the individual, may help avoid the more frequent glycaemic excursions associated with sport/physical activity: hypoglycaemia during exercise, post-exercise hyperglycaemia and hypoglycaemia in the post-exercise recovery period. In this regard, it is essential to estimate insulin on board in these periods.

The **intensity, duration and type of exercise** and corresponding individual metabolic response should be predetermined to consider specific adjustments to the insulin dose.

In addition, the increasingly widespread use of CGM permits current glucose levels to be established and the trend to be predicted in the following hours and thus considered in decision-making. (see Figure 3).

Figure 3: Recommendations for basal/intermediate and rapid pre-prandial, post-exercise (1-3 hours) insulin adjustment (excluding degludec) in three types of exercise.

Duración media (20-90 min) Intensidad baja/moderada (Aeróbico)				Duración media (20-90 min) Intensidad moderada/intensa (Anaeróbico)				Duración larga (>2 h) Intensidad baja (Aeróbico)			
Basal previa	Preprandial posterior		Basal posterior	Basal previa	Preprandial posterior		Basal posterior	Basal previa	Preprandial posterior		Basal posterior
	Tendencia	Ajuste			Tendencia	Ajuste			Tendencia	Ajuste	
- 0-30%	↑↗	-25%	= /-20%	- 20%	↑↗	=*	- 20-30%	- 30-50%	↑↗	-25%	= / -20%
	→	-50%			→	=*			→	-50%	
	↓↘	-75% / -100%			↓↘	-25% / -50%			↓↘	-75% / -100%	

*>250 “microbolus corrector” (50% Factor Sensibilidad Individual)
si glucosa >250mg/dL valorar un “microbolus corrector” (50% Factor Sensibilidad Individual)(5) Rápida preejercicio ver texto

Many sports (such as "padel" or indoor football) are **anaerobic** regardless of

their intensity and generate stress and high counterregulatory hormone levels.[56]This translates into transitory hyperglycaemia.[57] Therefore, prior insulin should not be reduced. However, reductions in post-exercise insulin are recommendable to minimise risk during the post-exercise recovery phase.[5] By contrast, with **aerobic exercise**, prior insulin should be reduced as glucose consumption is involved during the activity.[58]

This section focuses on **recommendations for administering basal and rapid-acting insulin separately** (basal-bolus schedules). Administration of basal nocturnal insulin helps reduce the risk of nocturnal hypoglycaemia after unplanned exercise, as adjustments can be made in the post-exercise recovery period.

Second-generation basal insulin (degludec, glargine U-300) has largely replaced previous ones in clinical practice thanks to their flatter profile, lower variability and longer duration of action. However, this long-acting profile, especially in the case of degludec insulin, reduces the options for making changes before moderate exercise. An experimental study showed that when moderate aerobic exercise is done for three consecutive days (>5 days), degludec insulin can be reduced by 25% three days before the event to help increase the TIR. 59 Other situations with degludec insulin can be managed with changes to CH supplements or adjustments to rapid-acting insulin.

If first-generation basal insulins (glargine U100, detemir) or even intermediate-acting insulin (NPH, NPL) are used in two daily doses, each dose can be adjusted differently. The dose immediately before and after exercise can be reduced in line with the above recommendations (type of physical activity) and the doses for the rest of the day maintained.

Glucagon for the prevention of exercise-induced hypoglycaemia

Changing insulin and carbohydrate intake usually is used to reduce the risk of hypoglycaemia during exercise, but it is not very effective.
Rickles et al. showed that a mini-dose of glucagon (150 mcg) administered subcutaneously before exercise can be more effective than reducing insulin to prevent hypoglycaemia in moderate exercise lasting 45 minutes.60 Another study showed that a 200 mcg improved glucose stability during 45 minutes of cycling.61 However, more studies are needed to confirm these results before the use of low-dose glucagon is generally accepted for exercise in people with diabetes.

RECOMMENDATIONS 5

Aerobic exercise

1. Reduce the day's prior basal insulin (except degludec)/intermediate insulin by at least 20% (target blood glucose: [126-160] mg/dL, depending on risk).. [62]
   - For fasted exercise or during the post-absorption period (>3 h after ingestion), assess larger reductions.
2. Adjust rapid-acting insulin6[63]
   - preprandial insulin before exercise (1-3 hours beforehand): Reduce by at least 25% for short-duration (<1/2 hour), 50% for intermediate duration (<1 hour) and 75% for prolonged exercise (>1 h).
   - preprandial insulin after exercise (1-3 hours afterwards): Assess a reduction of at least 25% for short-duration (<1/2 hour), 50% for intermediate duration (<1 hour) and 75% for prolonged exercise (>1 h).
   - For hyperglycaemic peak correction boluses: assess adding a 'correction microbolus' (50% of the individual correction factor) only when blood glucose levels are clearly high (>250 mg/dL)[5]

Anaerobic exercise

3. Reduce **basal insulin (except degludec)/intermediate insulin** after exercise by 20-30%.[63]
4. **Rapid insulin**
   - Preprandial insulin before activity (between 1-3 hours beforehand) and preprandial insulin after exercise (1 to 3 hours afterwards): Do not reduce.
   - For hyperglycaemic peak (generally short-lasting) correction boluses: assess adding a 'correction microbolus' (50% of the individual correction factor) only when blood glucose levels are clearly high (>250 mg/dL)[3]

6 NON-INSULIN DRUGS

In this section we will focus mainly on **patients with T2D**, since most non-insulin therapies are not authorized for clinical use in T1D.

Overall, the most frequent metabolic complication that a patient with T2D may develop is hypoglycaemia, although it is usually uncommon in the absence of insulin therapy.[11-64]

The **risk of hypoglycaemia** of antidiabetic drugs is closely associated with their mechanism of action. Thus, drugs that increase endogenous insulin secretion (secretagogues) are associated with a greater risk of hypoglycaemia, while drugs that do not increase insulin secretion are not usually associated with a higher risk of hypoglycaemia.[64] **Sulfonylureas and glinides are the drugs which are associated with the greater risk of hypoglycaemia** when practising physical exercise, especially with intense and prolonged (>60 minutes) exercise. Due to the longer duration of action of sulfonylureas, they have the higher risk of hypoglycaemia, although the risk is usually low. In general, the dose of these drugs does not need to be modified with sporadic exercise, although reducing the dose (or even stopping the drug) may be considered with regular and prolonged exercise in people with diabetes and adequate metabolic control.[65]

Metformin does not usually produce hypoglycaemia with physical exercise. However, it may occur after alcohol intake or in patients with severe liver of kidney impairment, as metformin suppresses hepatic glucose production.[66]

Acarbose and miglitol, reversible inhibitors of intestinal alpha-glucosidases, do not **usually induce hypoglycaemia**, but if it develops (due to the concomitant use of insulin or secretagogues), hypoglycaemia should be treated with glucose, as neither sucrose nor lactose would be effective. .[67]

The risk of hypoglycaemia with dipeptidil peptidase-4 (DPP-4) inhibitors and **GLP-1 receptor agonists** (GLP-1 RAs) **is very low**, as they stimulate pancreatic insulin secretion in a glucose-dependent manner, i.e. they do not stimulate endogenous insulin secretion at low blood glucose levels.[66]

Pioglitazone is a drug that increases peripheral insulin sensitivity, but it does not stimulate insulin secretion by pancreatic β-cells. Therefore, the use of pioglitazone during exercise will probably **not produce hypoglycemia**.[66]

Finally, **sodium-glucose cotransporter-2 (SGLT2) inhibitors have an inherently low risk of producing hypoglycaemia**, as they do not increase insulin secretion or inhibit the counterregulatory response to hypoglycaemia. However, due to their mechanism of action, these drugs are associated with a higher risk of dehydration, hypovolemia and ketosis/ketoacidosis. Thus, it should be considered to discontinue SGLT2 inhibitors before intense and prolonged physical exercise. [68]

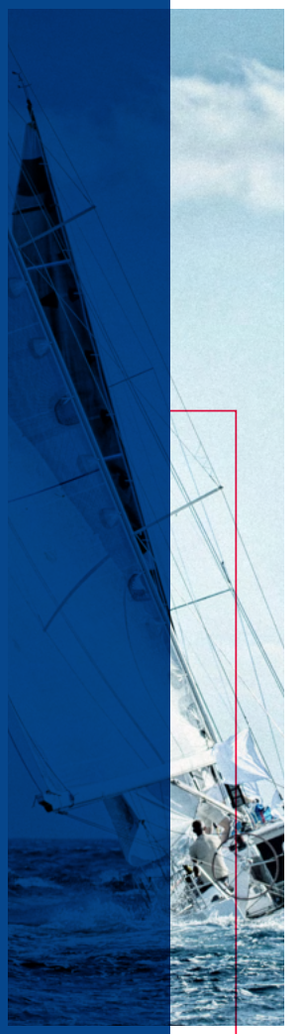
RECOMMENDATIONS 6 (Table 10)

1. Hypoglycaemia is the most frequent metabolic complication in patients with diabetes who do physical exercise, although in the absence of insulin treatment, its appearance is infrequent.
2. Non-insulin therapies which are associated with a higher risk of hypoglycaemia are those that increase endogenous insulin secretion (sulfonylureas and glinides), although the overall risk is usually low.
3. Although SGLT2 inhibitors do not produce hypoglycaemia, they are associated with a higher risk of dehydration, hypotension and ketosis/ketoacidosis.
4. Before intense, prolonged exercise (>60 minutes), it is advisable to reduce the usual dose or even discontinue the administration of sulfonylureas/glinides, and SGLT2 inhibitors.

Table 10: Antidiabetic drugs and considerations for physical exercise.

Medicación	Riesgo de hipoglucemia	Consideraciones de ajuste de dosis
Sulfonilureas	++	Si hipoglucemia, reducir dosis o suspender
Glinidas	+	Si hipoglucemia, reducir dosis o suspender
Metformina	-	No necesario
Pioglitazona	-	No necesario
Acarbosa-Miglitol	-	No necesario
iDPP4	-	No necesario
Ar-GLP1	-	No necesario
iSGLT2	-	Suspender ante ejercicio físico intenso y duradero (riesgo deshidratación, hipotensión, cetosis/acidosis)

iDPP4: Inhibidores de DPP4; **Ar-GLP1:** Agonistas del receptor de GLP-1; **iSGLT2:** Inhibidores del cotransportador de sodio-glucosa tipo 2

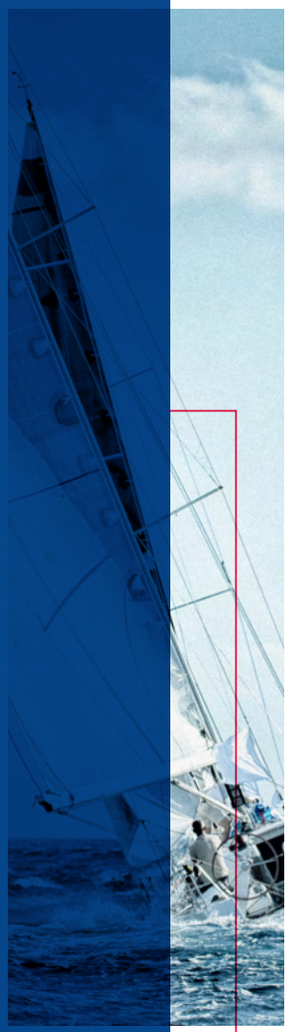


7 PEOPLE WITH DIABETES ON CONTINUOUS SUBCUTANEOUS INSULIN INFUSION

Continuous subcutaneous insulin infusion (CSII) therapy and especially integrated CSII+CGM systems facilitate diabetes management in exercise. Both the basal rate (BR) and boluses can be modified and adapted to the type and time of exercise. In the case of CSII+CGM, alarms and predictive insulin suspension provide protection from hypoglycaemia during and some hours after exercise[5,69].

Practical aspects to consider:

- Choose the insertion site for the CSII catheter and the CGM sensor avoiding areas that may receive impacts or cause rubbing or friction[1].
- In the case of high-altitude sports, check for bubbles forming in the CSII catheters[3]. CGM systems have proven reliable at altitudes up to 3600 metres, although it is advisable to check them frequently, ensuring they are not exposed to very low temperatures[54].
- In general, CSII disconnection is not recommended, but may be necessary in some sports (e.g. water and contact sports)[1].
- In case of disconnection, try to ensure this is for no longer than 1-2 hours. Before the disconnection, administer a bolus equivalent to the sum of the BR in the disconnection period x 1.25, applying a 20-50% reduction. When disconnecting for >3-4 hours, administer the calculated dose, injecting a short-or intermediate-acting insulin (regular, NPH or detemir) 30-60 minutes before disconnection and applying the same percentage of reduction. In case of long duration moderate-intense exercise several days on a week, BR can be reduced by 50% and the other 50% injected in the form of long-acting insulin (glargine u100, glargine u300 or degludec).[70]
- In high-intensity exercise, a correction bolus around 50% of the calculated dose might be requiered at the end of the exercise, to prevent subsequent hyperglycaemia[71].
- In the case of CSII+CGM, check the IG value and the trend arrow frequently. However, bear in mind the physiological delay in IG compared to CBG[3].
- In the case of high-risk and high-intensity sports, an increase in the insulin suspension threshold in CSII-CGM systems (80 mg/dL), maintained until 90 minutes after finishing, is recommended to avoid hypoglycaemia as much as



possible. In the case of hybrid closed loop systems, the exercise mode may be used (150 mg/dL or 140-160mg/dL or +70 mg/dL over the ideal configured target depending on the device).[1,55] Some of these devices require that type and intensity of the exercise be announced at least 60 minutes in advance.

- Doing exercise in the morning instead of the afternoon can reduce the risk of hypoglycemia in the following hours in people on CSII+MCG.[27].

Adjustments of the BR (Table 11)[2,3,50,9]:

- Planned exercise:
  - 60-90 minutes before exercise, start temporary BR (-20 to -50% reduction). This can be modified depending on CBG or IG and their trend on starting the exercise. It may also be necessary to take CH.
- Unplanned exercise:
  - Start temporary BR with higher reduction (-30 to -80%) depending on CBG/IG and trend it for the whole period of exercise. CH intake is generally necessary.
- After ending the exercise:
  - In general, the temporary BR can be ended when CBG or IG >100-120 mg/dL (for some time it may be necessary for up to 12 hours depending on the exercise).
  - A temporary BR (reduction ≈ 20%) with or without CH intake can be used to avoid nocturnal hypoglycemia.

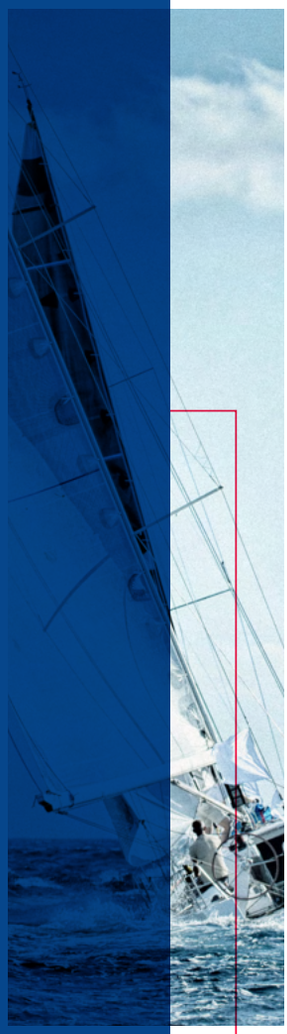


Table 11: Recommended adjustments to the BR and CH supplements in CSII+MCG/CGM users before doing planned or unplanned exercise.

Ejercicio planificado			
GC/GI 60-90 minutos pre-ejercicio	Reducción TB (temporal) 60-90 minutos antes del ejercicio	GC/GI al empezar el ejercicio	Ingesta HC al iniciar el ejercicio
<70 mg/dL	50%	<70 mg/dL	10-20 g sin bolo
70-150 mg/dL	30-50%	70-150 mg/dL	10-20 g y mitad bolo calculado
> 150 mg/dL	20-30%	> 150 mg/dL	No es necesario
Ejercicio no planificado			
GC/GI pre-ejercicio	Reducción TB (temporal)	GC/GI al empezar el ejercicio	Ingesta HC al iniciar el ejercicio
<70 mg/dL	70-80%	<70 mg/dL	20 g sin bolo
70-150 mg/dL	50%	70-150 mg/dL	10-20 g sin bolo
> 150 mg/dL	30%	> 150 mg/dL	No es necesario

TB: tasa basal; **ISCI:** infusión subcutánea continua de insulina; **MCG:** monitorización continua de glucosa; **GC:** glucemia capilar; **GI:** glucosa intersticial; **HC:** hidratos de carbono

Bolus adjustments (Table 12) [1,5,54, 72,73]:

- Planned exercise:
  - When the exercise is to be performed <2-3 hours after a prandial bolus, this should be reduced depending of intensity (-25 to -75% of reduction). This reduction can be previously configured in the CSII bolus calculator.
- Unplanned exercise:
  - Once the bolus has been administered, it is recommendable to adjust the BR (see previous section) with or without CH intake.
  - It is recommended to reduce by 50% the prandial bolus of the next meal after the end of the exercise.

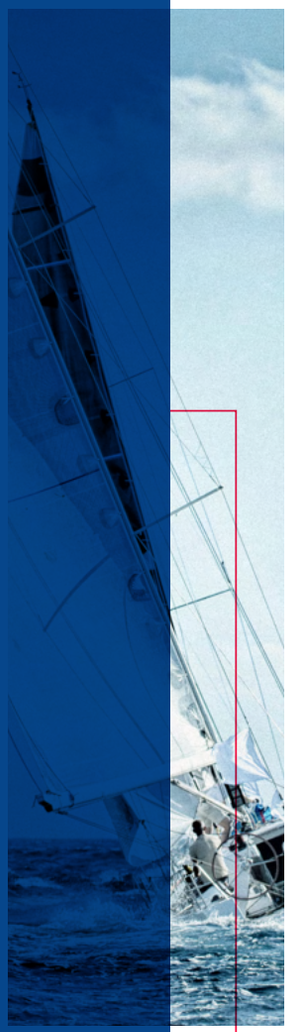


Table 12: Recommended adjustments of the prandial bolus when exercise is planned <2-3 hours after the bolus administration

Tipo de ejercicio planificado 2-3 horas tras bolo prandial		
Ejercicio aeróbico baja-moderada intensidad	Ejercicio anaeróbico de baja moderada-intensidad	Ejercicio anaeróbico intenso
Reducir 25% si intensidad baja Reducir del 50% a -75% si intensidad moderada	Puede no precisar ajuste; valorar -25 a -50% según cambio de glucosa esperado por experiencias previas	No requiere ajuste Considerar añadir pequeña corrección si GC/GI elevada

GC: Glucosa capilar, **GI:** Glucosa Intersticial; **ISCI:** infusión subcutánea continua de insulina; **MCG:** monitorización continua de glucosa

RECOMMENDATIONS 7

1. In planned exercise, use a temporary BR with a % of reduction before starting exercise. The bolus should be reduced if the activity is to be carried out <2-3 h after its administration.
2. In unplanned exercise, use a temporary BR with a % of reduction and CH supplement intake.
3. After completing the exercise, the temporary BR can be ended when the CBG or IG value reaches >100-120 mg/dL. Some sports may require CSII disconnection.
4. In high-intensity exercise, a correction bolus might be necessary after CSII reconnection.
5. If a CGM system is used, check the IG value and its trend frequently.
6. In case of use of CSII + CGM with predictive insulin suspension, it is recommedable to raise the suspension threshold in high-intensity exercise. When an hybrid closed-loop system is used, it is recommendable to use the particular exercise mode.

8 EXERCISE TRAINING GUIDELINES

Exercise training in people with diabetes involves two key aspects:

1. The physical training itself to incorporate and increase physical ability

2. The training to minimize hypo/hyperglycemic events. This will require specific therapeutic training, mainly: carbohydrate and insulin dose adjustment and blood glucose monitoring (all these points have already detailed in another section of this guideline).

This training will be more complex for people on intensive insulin therapy and without pancreatic reserve. The situations in which training exercise should not be started are showed at Table 13.

Table 13: List of situations in which people with diabetes should not start physical training

PEOPLE WITH DM MUST CHECK THIS LIST BEFORE START their TRAINING. This is especially important for some special situations: elderly/fragile patients; patients with comorbidities/complications, patients on insulin/ sulfonylureas /repaglinide treatment or when exercising with high intensity, long duration or in extreme conditions.

PLEASE: CLICK in the QUESTION, CIRCLE YOUR ANSWER (YES or NO) and ACT ACCORDING to the ANSWER as indicated.

CHECK-LIST GENERAL

☐ **Did I have a MEDICAL ASSESSMENT* of my DIABETES before starting SPORTS TRAINING?** *Assessment of glycemic control: HbA1c,TIR, variability, complications and comorbidities (that make certain typesof exercise inadvisable) and preferably reinforcement of self-management for DM [2,3,12].

- **YES = GO AHEAD.** (training is safe).

- **NO = STOP TRAINING.** Solve the problem and then start training (a medical-sporting assessment should be carried out before starting training)

☐ **IDENTIFICATION of DM**. DOES ANYONE IN MY TRAINING ENVIRONMENT KNOW THAT I HAVE DIABETES / COMPLICATIONS / CO-MORBIDITIES?**

** This is especially important for special populations and high intensity / long duration / extreme exercise conditions. It is preferable: NOT to train ALONE, that someone from the environment knows the clinical condition (or carry some sort of DM identification) and knows how to manage hypoglycemia situations)[1,6].

- **YES = GO AHEAD** (training is safe).

• **NO = STOP TRAINING.** Solve the problem and then start training.

☐ **AM I CARRYING MY TECHNICAL EQUIPMENTS (meters, injectors etc.) AND DRUGS BEFORE STARTING TRAINING?**

• **YES = GO AHEAD** (training is safe).

• **NO = STOP TRAINING.** Solve the problem and then start training.

☐ **AM I ON TREATMENT WITH INSULIN or WITH ORAL MEDICATION THAT COULD INDUCE HYPOGLYCAEMIA? (sulfonylureas, repaglinide)**

• **YES, I AM ON THESE DRUGS = STOP TRAINING.** Solve the problem and then start training. Before start training, ask your medical team about the possibility of substituting these medications for others that do not produce hypoglycemia. If that is not possible: reduce the dose before starting exercise and measure blood glucose as indicates elsewhere to establish personal strategies to avoid hypoglycemia.

• **NO, I am not on THESE DRUGS = GO A HEAD** (training is safe).

☐ **DO I KNOW HOW TO IDENTIFY HYPOGLYCEMIA AND HOW TO MANAGE IT?**

• **YES = GO AHEAD** (training is safe).

• **NO = STOP TRAINING.** Solve the problem and then start training. All people with diabetes on treatment with hypoglycemia-inducing drugs (insulin, sulfonylureas, repaglinide) should know how to manage hypoglycemia as an essential part of their therapeutic education on diabetes[12].

☐ **DO I HAVE BLOOD GLUCOSE ≤70 mg/dL (<3.0 mmol/L) before starting TRAINING?**

• **YES = STOP TRAINING.** Solve the problem and then start training. Follow the recommendations indicates elsewhere on this guideline.

- People with diabetes must have received diabetic education, regardless of whether they do physical training, in order to self-manage these situations[12].
- Follow the indications for action, recommended in the corresponding section in these guidelines.

• **NO = CO GO AHEAD,** (training is safe).

☐ **DO I HAVE A SEVERE HYPOGLYCEMIA in the last 24-48 hours / 6 months BEFORE TRAINING?**

• **YES = STOP TRAINING.** Solve the problem and then start training.

- Follow the recommendations indicates elsewhere on this guideline and/or consult with your therapeutical team. All people with diabetes on treatment with hypoglycemia-inducing drugs should know how to manage hypoglycemia as an essential part of their therapeutic education on diabetes.[12].
- EXERCISE SHOULD BE AVOIDED IN THE 24 HOURS FOLLOWING SEVERE HYPOGLYCEMIA due to the substantially greater risk of a major severe episode during exercise[1,2,6].
- In addition, if an episode of severe hypoglycemia has occurred in the previous 6 months, there may be a high risk of hypoglycemia during exercise[4].

• **NO = GO AHEAD** (training is safe).

☐ **DO I HAVE VERY HIGH BLOOD GLUCOSE? (≥270 ng/mL/ ≥15.0 mmol/L)?**

• **YES = STOP TRAINING.** Solve the problem and then start training.

- If glucose levels are very high before exercise (≥15.0 mmol/L [270 mg/dL]), blood ketone levels should be monitored and an insulin correction may be administered based on the individual's correction factor (new consensus).
- It is preferable to determine ketones in blood rather than urine due to the latter's lower sensitivity and specificity for detecting diabetic ketoacidosis.[2,12]
- People with diabetes (specifically type 1 diabetes or on intensive insulin treatment) should know how to manage this situation as part of their therapeutic education on diabetes.[12]

• **NO = GO AHEAD** (training is safe).

☐ **KETONAEMIA** (especially for patients with T1D/pancreoprivic diabetes) - Are high Ketone levels present in blood (≥1.5 mmol/L) or urine (≥2+ or ≥4.0 mmol/L)? (preferably determined in blood)[12,13].

• **YES = STOP TRAINING.** Solve the problem and then start training. IF YOU HAVE HIGH KETONE LEVELS IN BLOOD (≥1.5 mmol/L) or URINE (≥2+ or ≥4.0 mmol/L): PHYSICAL EXERCISE IS CONTRAINDICATED.

- It is preferable to determine ketones in blood rather than urine because of the lower sensitivity and specificity of urine for detecting diabetic ketoacidosis [2,12]

- People with diabetes (especially with type 1 diabetes or on intensive insulin therapy) should know how to manage this situation as part of their diabetes therapeutic education.[12]

- If the situation persists, the patient must contact with an emergency medical service or, if available, their therapeutical team. [1, 2,12.]

• **NO = GO AHEAD** (training is safe).

☐ **DO I HAVE AN ACUTE INTERCURRENT ILLNESS?**

• **YES = STOP TRAINING.** Solve the problem and then start training. IF YOU HAVE AN ACUTE INTERCURRENT ILLNESS, PHYSICAL EXERCISE IS CONTRAINDICATED

- People with diabetes (specifically type 1diabetes or on intensive insulin treatment) should know how to manage this situation as part of their therapeutic education on diabetes.[12].

• **NO = GO AHEAD** (training is safe).

☐ **HYDRATION. I AM CARRYING WATER OR FLUIDS WITH ELECTROLYTES AND GLUCOSE?** . (especially with prolonged, high-intensity exercise and extreme conditions).[1-5]

• **YES = GO AHEAD** (training is safe).

• **NO = STOP TRAINING.** Solve the problem and then start training. Follow the recommendations indicates elsewhere on this guideline and/or consult with your therapeutical team.

Physical training

Physical training is a planned and complex process that involves progressive and incremental workouts that stimulate the development of different physical capacities (endurance, strength, speed, flexibility, and others). Its effects are reversible. [18] The glycemic response to exercise depends on both diabetes-related variables and physical activity-related factors; furthermore, there is a large difference in individual response and the recommended ranges of adjustment are very wide, so patients will need tailored adjustments. [5,13,15,20] Training is the best time to analyze the evolution of each individual's blood glucose levels and make decisions. [5,15] As physical training progresses, the athlete's physical capacity changes, as does the amount of CH needed and the dose and timing of insulin administration, so further modifications may be necessary. Competition days may have different adaptations due to stress and may again require new changes. Finally, there are a number of sports (mountain climbing, diving, etc., mentioned elsewhere in this guide) where there is a greater tendency for hyperglycemia due to the situation and excess of counter-regulatory hormones, regardless of the type of exercise; again, training helps to make these adjustments. [5,15]

Recommendations for before, during and after training

Each training session should consist of 3 stages: first, warm-up; second, core training (workouts); and third, cool-down and stretching. Table 14 summarises the procedure for glycaemic control, which should be carried out before, during and on concluding training. Specific procedures in decision-making (adjustments to CH intake and insulin, and times for their administration and monitoring blood glucose) are detailed elsewhere in these guidelines.

Table 14: Assessments to carry out before, during and after training

EL ENTRENAMIENTO SE DIVIDE EN 3 PARTES

1	2	3
CALENTAMIENTO	**NÚCLEO DEL ENTRENAMIENTO (CARGAS DE TRABAJO)**	**VUELTA A LA CALMA Y ESTIRAMIENTOS**

VALORACIONES a REALIZAR (ANTES, DURANTE y DESPUÉS DEL ENTRENAMIENTO)

1

VALORACIONES a REALIZAR ANTES DEL ENTRENAMIENTO:

1. REVISAR la LISTA GENERAL de SITUACIONES DE NO HACER EJERCICIO (TABLA 13)

2. REVISAR las VARIABLES, DEPENDIENTES de la DM para matizar contraindicaciones para el entrenamiento o el riesgo individual de hipoglucemia

- SI HAY TRATAMIENTO CON INSULINA ó SECRETAGOGOS O si existe variabilidad y tendencia intrínseca a hipoglucemias (y si estas se perciben correctamente)
- SI HAY COMPLICACIONES/ CO-MORBILIDADES QUE CONTRAINDIQUEN ALGÚN TIPO DE EJERCIO
- Revisar las VARIABLES esenciales PARA LOS AJUSTES DE CH /INSULINA: MEDIR GLUCEMIA (GLUCEMIA DE PARTIDA), TIEMPO DESDE LA ÚLTIMA INGESTA Y CANTIDAD DE INSULINA CIRCULANTE.

3. REVISAR las VARIABLES, DEPENDIENTES DEL EJERCICIO que PUEDEN INDUCIR CAMBIOS EN LA GLUCEMIA durante el entrenamiento.

- TIPO DE EJERCICIO: AERÓBICO, MIXTO, ANAERÓBICO
- INTENSIDAD Y DURACIÓN del EJERCICIO

4. REVISAR la CONDICIÓN FÍSICA que tiene la persona con DM, para fijar punto de partida del entrenamiento (duración e intensidad del entrenamiento).

TOMA DE DECISIONES INICIAL (de ANTES DEL ENTRENAMIENTO)
(cantidad de HC/ modificaciones en la DOSIS DE INSULINA/ tiempos de administración)
VALORAR realizar SPRINTS +/- CAFEINA (5-6 mg/kg) ANTES del núcleo de entrenamiento para minimizar hipoglucemia

2

VALORACIONES a realizar en el NUCLEO DEL ENTRENAMIENTO

1. VERIFICAR durante el entrenamiento la INTENSIDAD y tipo del ejercicio. Con cada cambio de intensidad y duración, se deben volver a analizar la respuesta glucémica y re-calcular ajustes si fuera necesario [2,3]

2. MONITORIZAR la GLUCEMIA de forma PERIÓDICA. (cada 1h si es de baja intensidad; cada 20-30 min si es de intensidad moderada o alta)

3. INICIAR el ENTRENAMIENTO en SESIONES de BAJA INTENSIDAD y TIEMPO CORTO 1º se sube la frecuencia del entrenamiento, luego el tiempo/volumen y por último la intensidad

TOMA DE DECISIONES (a realizar DURANTE el NÚCLEO del ENTRENAMIENTO)
(fundamentalmente ajustar toma de HC)
Al progresar en el entrenamiento: se tiene que volver a analizar la respuesta glucémica y recalcular ajustes si fuera necesario

VALORACIONES a realizar al FINALIZAR el ENTRENAMIENTO

(I) MONITORIZACIÓN DE GLUCEMIAS DESPUÉS DEL ENTRENAMIENTO (de forma precoz y tardía),

3

- **TOMA de DECISIONES FINAL PARA DESPUÉS DEL ENTRENAMIENTO:** cantidad de HC/ modificaciones en la DOSIS DE INSULINA/ tiempos de administración
- **ANALIZAR la GLUCEMIA RESULTANTE DURANTE y DESPUÉS del ENTRENAMIENTO CON LOS AJUSTES REALIZADOS** al iniciar y durante el entrenamiento
- **RECALCULAR NECESIDADES SI SE PRECISA EN PROXIMO ENTRENAMIENTO**

Recommendations for progression in training

Training should progress gradually to minimise the risk of injury and dysglycaemia. The rhythm of progression must be gradual and set by both physical condition (slower progression with a poorer starting condition) and the clinical condition (slower progression with more age, fragility, duration of diabetes, presence of complications and comorbidities and type of pharmacological therapy). As a general rule, people should start at low intensity and short times, first increasing the frequency (number of sessions/week), then the volume of exercise and time of each session, and finally the intensity.[5,18].

Intensity and progression in aerobic exercise

Activity should start with short, low-intensity exercise[5,13,15,19] (%MHR <40-50%); e.g. start with 1-2 20-40 min sessions/week with an MHR <40-50% for 2-6 weeks. The training cycle for each session should be observed (warm-up/core training/stretching) and the rules of progression (frequency, time, intensity). The end goal of training is the same as stated by the WHO for the general healthy population: minimum end goal of 150 min/week of moderate to high intensity (%MHR >50-70); 3 days a week, with no more than 2 consecutive days without activity.[13] Shorter exercises (minimum 75 min/week) and vigorous or high-intensity interval training (HIIT) may be enough for young, fit individuals.[1,2,4]. The benefits of exercise are greater if aerobic exercises are combined with muscle strength exercises (e.g. doing each exercise group on alternate days) rather than doing just one group.[5,13,15]. The benefits are even greater if non-structured physical activity (walking, going upstairs, leisure activities) is combined with exercise (structured physical activity).[13,15]

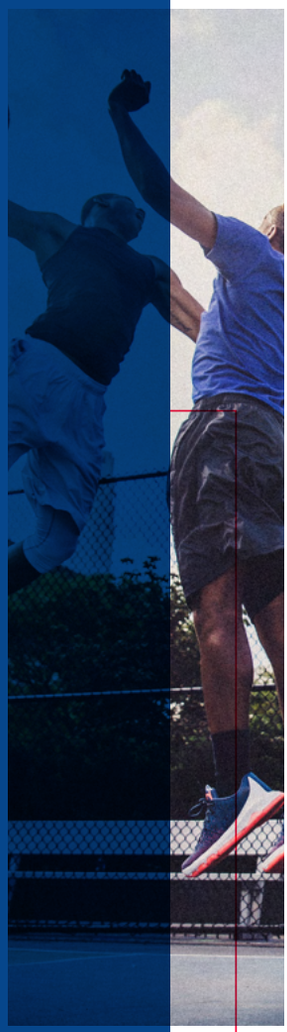
Intensity and progression in strength-resistance exercise

Inhaling-exhaling cycles should be coordinated with the muscle movement; avoid Valsalva and control blood pressure correctly. The training and progression sequence are maintained. Each training session consists of several exercises, each with several series of repetitions (with a resting time of 1-2 minutes after each series), which should cause fatigue in the associated muscle group.[18] It should start out at low intensity and short periods (equivalent to starting adaptation exercises with little or no weight). Training should progress slowly, increasing first the weight then the number of repetitions. Training should be done with a minimum target of 2 sessions a week (preferably 3) on non-consecutive days, alternating with aerobic exercise on the rest days for the strength programme (ADA recommendation level A).[5,13,15] The end goal for intensity, in the absence of contraindications: 75-80% maximum effort, which provides the

best cardiometabolic benefits.[13] For instance, a good goal might be to progress over 6 months to 3 weekly sessions of 8-10 exercises with 8-10 repetitions performed at 75-80% maximum strength (intensity). **Balance** exercises benefit gait and prevent falls, and are especially recommended for elderly people with diabetes (which, depending on preferences, may include activities such as tai chi and yoga, which combine flexibility, balance and resistance).

RECOMENDACIONES 8

1. A number of assessments should be performed before, during and after training in order to make adjustments (Table 14).
2. Training should start with short, low-intensity sessions and **progress gradually.**
3. Training should **combine aerobic** with **strength exercises** on alternate days.
4. Whenever possible, it should be associated with (but nor replaced by) **flexibility** exercises. In elderly people with diabetes, combine flexibility and balance training 2-3 times a week.
5. Whenever possible, increase unstructured physical activity between training sessions, as this provides extra health benefits.[5,13,15].



9 PECULIARITIES OF SPECIFIC SPORTS

Divers

Diving in patients with diabetes involves two potential hazards: possible predisposition to decompression sickness (although this has not been proven) and more risk of hypoglycaemia going unnoticed than on the surface, with the consequent risk of drowning. However, people with diabetes can go diving safely as long as they follow a number of conditions. Several guidelines cover this aspect.[50,78]. Table 15 is based on the recommendations of these guidelines.

Cases of IGM being effectively used during successive dives have also been published.[51]

Good hydration is very important to prevent decompression sickness and subjects with diabetes should readjust their dive computers to more conservative safety limits.

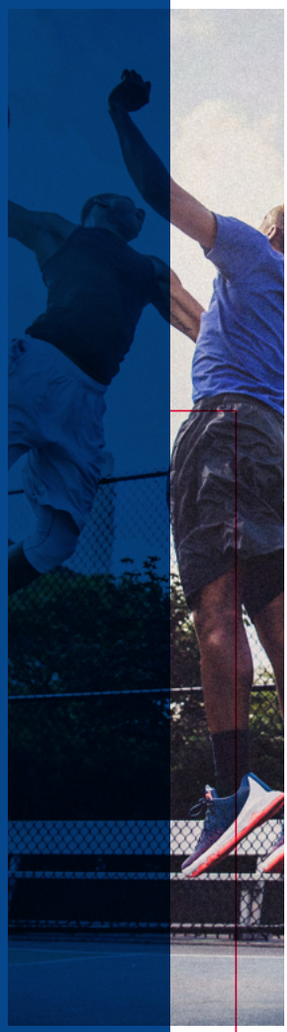
Table 15: Recommendations for diving in patients with diabetes

Criterios a cumplir antes de bucear

- Terapia farmacológica estable: más de 3 meses con fármacos orales o más de 1 año en insulinoterapia.
- No episodios de hipoglucemia o hiperglucemia grave en el último año
- No historia de hipoglucemias no percibidas.
- HbA1c < 8 % durante el mes previo a la inmersión.
- No complicaciones metadiabéticas significativas.
- En sujetos > 40 años descartar cardiopatía isquémica silente.

Tipo de inmersión a realizar

- Menos de 25 mts de profundidad (y menos de 60' de duración).
- No precisar paradas de descompresión.
- Evitar lugares confinados (cuevas, pecios, cenotes).
- Evitar situaciones que favorezcan hipoglucemia
- Compañero de buceo y guía advertidos y adiestrados en manejo de hipoglucemia.
- Compañero de buceo sin DM.



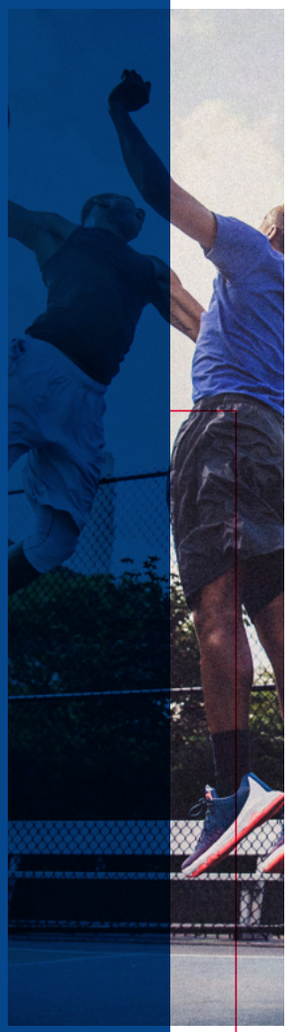
Manejo Glucemia el día de la inmersión

- **Tomar suplemento HC 1.5 ó 2 hs antes** de la inmersión (reducir la dosis habitual de insulina entre un 10-30 %).
- Medida glucemia 60'-30' y 10' antes de inmersión (la tendencia glucémica debe ser estable o en aumento).
- Objetivo glucémico: 180-250 mg/dL antes de la inmersión.
- Medicaciones:
  - Portar glucosa (líquido o gel) en chaleco de buceo.
  - Disponer de glucagón en superficie.
- Si hipoglucemia en inmersión:
  - Señal a compañero (índice y pulgar en "L")
  - Toma de glucosa e inicio lento de ascenso a superficie.
  - En superficie, administración de glucagón si es preciso.
- Si pérdida de conciencia bajo el agua:
  - Asegurar la posición del regulador en la boca del diabético e iniciar el ascenso lo antes posible.
  - En superficie, administración de glucagón.
- Medida glucosa cada 3 hs durante las 12 hs siguientes a la inmersión.
- Hidratación importante los días de buceo (más de 3 litros/día).
- Registrar en diario de buceo todos los datos de la inmersión: autoanálisis, dosis de fármacos, ingesta, etc...para ajustar futuras inmersiones

Mountaineers

There are no data to contraindicate mountaineering in people with well controlled diabetes. However, at high altitudes people with diabetes are at greater risk of dehydration, hypothermia (due to hypoglycaemia, and alterations to thermogenesis), freezing or injuries due to the cold.

- Mountain sickness (MS): no increased risk of MS has been reported in patients with diabetes. Treatment and prevention of MS is the same for subjects without diabetes,[79] except that acetazolamide is not recommended in people with T1D due to a theoretical risk of acidosis.
- Glycaemic control: Insulin needs and blood glucose levels increase (possibly due to the effect of counterregulatory hormones),[80,81] making it recommendable to reduce the dose of insulin or oral drugs. Furthermore, above 5000 meters gastric emptying is delayed, so prandial insulin should be given after eating. It should be borne in mind that cold can reduce subcutaneous absorption of insulin and contribute to increasing insulin needs. The symptoms of hypoglycaemia may be confused with typical MS, so a target of 110-220 mg/dL should be maintained with frequent self-tests and supplements taken every hour. After a day of heavy physical exertion, glycogen stores may be depleted, and glucagon administration would be ineffective.
- Dehydration: large fluid intake should be maintained (more than 4 L/day).
- Frostbite: This should be prevented by means of proper nutrition, hydration, checking feet daily and using proper footwear and gloves.



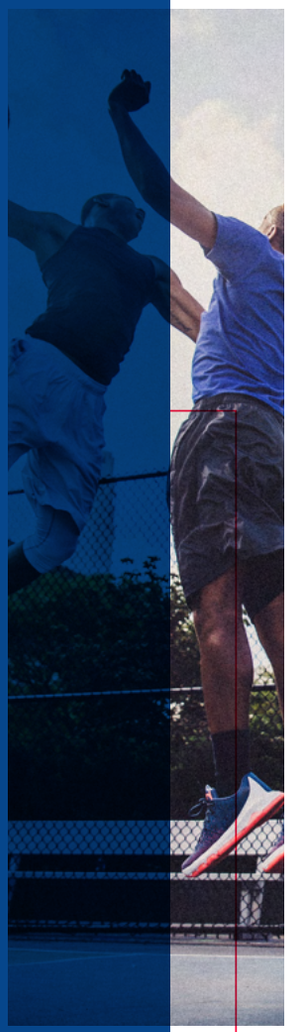
- Retinopathy: This can worsen at altitude. It is therefore advisable to have an eye examination before and after climbing to high altitudes. These complications can be prevented by taking the ascent slowly.[82].
- Thyroid function: There is greater thyroid activity at altitude, so prior thyroid dysfunction should be ruled out or treated if present (even if subclinical).[83].
- IGM: this can be reliable up to 3600 m. There are no data to recommend safe IG levels.[54] Frequent glucose sensor readings or scans in the case of FGM are recommendable and, if hyperglycaemia occurs, correct with 50% of the usual dose. Avoid placing the sensor in sites with too much exposure to the cold.
- Practical aspects. Insulin and glucagon should be prevented from freezing by storing them in bags attached to the body;[84] the ascent itself can cause bubbles to appear in the insulin, which must be purged. Needles should be removed from the pen after injections, as variations in pressure may cause the fluid to be expelled and alter the consistency of the insulin solution. Use nasal glucagon (it does nor freeze and is not adequately conserved at up to 30 degrees).

Sailors

People with diabetes who go sailing should always be accompanied, while being fully aware of and preventing the risk of hypoglycaemia, particularly for sailing in small boats with only two crew members (only 1 partner) and where greater physical effort is required (dinghy sailing). The partner should be trained in how to give glucagon if necessary. All equipment for glycaemic control should be kept in a watertight container which floats; it is advisable to add desiccants to absorb moisture and it should be kept refrigerated.

Endurance athletes (runners/skiers/cyclists)

In endurance sports, it is important to bear in mind the risk of hypoglycaemia (during the activity and several hours afterwards), dehydration and heatstroke or hyperthermia. The athlete should drink between 0.4-0.8 L/hour of water or isotonic drinks (add CH if exercise lasts longer than one hour), limit sweating by avoiding excessively warm clothing, and prevent heatstroke (with excessive temperatures) by wearing caps for protection, frequently refreshing, staying well hydrated, avoiding the hottest times of day, using breathable, airy clothing etc.

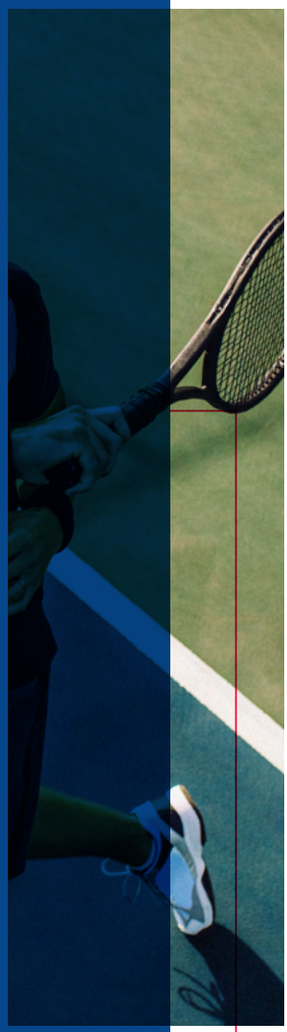


Swimmers

Above all, hypoglycaemia should be prevented, as this would lead to the risk of drowning. If swimming for more than half an hour, CH supplements should be taken (glucose gels) that can be stowed in a bathing suit and cap. The activity should be stopped at the slightest symptom of hypoglycaemia; the swimmer should take CH and get out of the water quickly. Use a waterproof bag to carry readers and permit scans while swimming, in the case of long-distance swimmers.

RECOMMENDATIONS 9

1. **Divers:** start at a blood glucose level >180 mg/dL. At the first sign of hypoglycaemia: alert the buddy and stop diving. Dive only according to the recommended safety margins for patients with diabetes. Go with a buddy who is informed and trained in managing hypoglycaemia.
2. **Mountaineers:** do not reduce the drug dosage; stay hydrated; protect against the cold, especially the feet; and check blood glucose frequently. Keep insulin and glucagon from freezing. No increased risk of AS. Acetazolamide not recommended in T1D.
3. **Endurance athletes:** preventative reduction in dose of hypoglycaemic agents. Adequate hydration. Supplements and self-monitoring every hour. Prevent heat stroke.
4. **Sailors:** do not go sailing alone. Supplements and self-monitoring every hour.
5. **Swimmers:** start at blood glucose level >180 mg/dL. With suspected hypoglycaemia: stop the activity, take supplements (stow gels in the bathing suit) and get out of the water.



10 EXERCISE IN ADOLESCENTS WITH TYPE 1 DIABETES

Physical exercise can improve glycaemic and lipid control, physical ability and quality of life in children and adolescents, as well as permit lower total doses of insulin. Family support is essential to maintain an active lifestyle and both young people and their parents should participate actively with the healthcare team.

During exercise, CGM and FGM may distort dynamic changes in real blood glucose concentrations due to the delay between blood glucose and interstitial glucose levels.

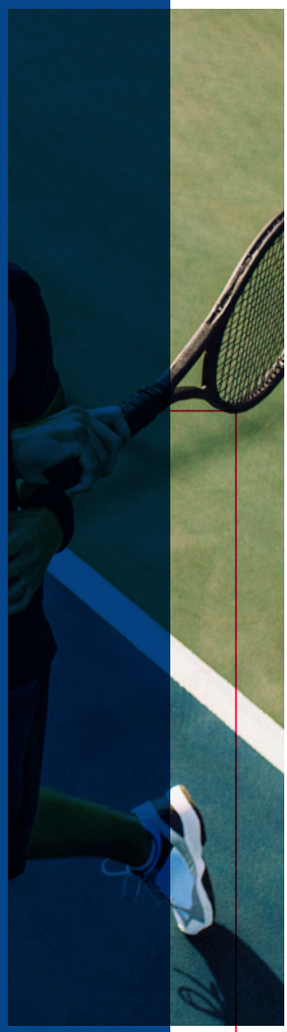
The CSII that includes predictive control systems for low glucose may be beneficial, given that physical activity is associated with a greater risk of hypoglycaemia, not just during but also after physical activity.

It is recommendable to establish hypo/hyperglycaemia alerts in ranges of 100-180 mg/dL or tailored to the individual and favour use of remote monitoring (e.g. mobile apps) which reduces parents' and carers' stress and concern.

CH supplementation should be tailored and adjusted to body weight.[3,20] Table 16 gives recommendations for treatment with insulin and CH for exercise in children and adolescents with T1D adapted to ESAD, ISADP and ADA guidelines.[20]

Table 16: Recommendations for treatment with insulin and carbohydrates for exercise in children and adolescents with T1D

Tratamiento	Tipo/intensidad del ejercicio Duración hasta 30-45 minutos	Tipo/intensidad del ejercicio Duración>45 minutos
MDI/ISCI: Bolo preprandial	-25% ejercicio leve -50% ejercicio moderado -50% ejercicio intenso aeróbico -25% ejercicio mixto aeróbico/anaeróbico Hasta -50% post ejercicio	50% ejercicio leve -75% ejercicio moderado -75% ejercicio intenso aeróbico -50% ejercicio mixto aeróbico/anaeróbico Hasta -50% post ejercicio
MDI Insulina basal[a]	- 20% en ejercicio tarde/noche	-20% en ejercicio tarde/noche -30-50% actividad inusual[a]
ISCI	Hasta -50% 90 min pre- ejercicio Suspensión bomba (<60 min) -20% durante la noche post ejercicio[b]	Hasta -80% 90 min pre- ejercicio Suspensión bomba (<60 min) -20% durante la noche post ejercicio[b]
Ingesta de HC[c]	-10-15g HC -1,5g HC/k peso/hora en ejercicio intenso -0,4 g HC/k peso antes dormir si ejercicio vespertino	



MDI: Múltiples dosis de Insulina; **ISCI:** Infusion Continua Subcutánea de Insulina; **HC:** Hidratos de carbono

Adaptado de *"position statement EASD, ISPAD, ADA. 2020"* [20]
a La dosis de insulina basal debería reducirse el día previo y el día del ejercicio, excepto en caso de empleo de degludec
b La insulina basal debería reducirse 20% antes de dormir si se realiza ejercicio por la tarde/noche, dependiendo de la duración e intensidad del ejercicio, excepto en caso de empleo de degludec

Preparation prior to exercise

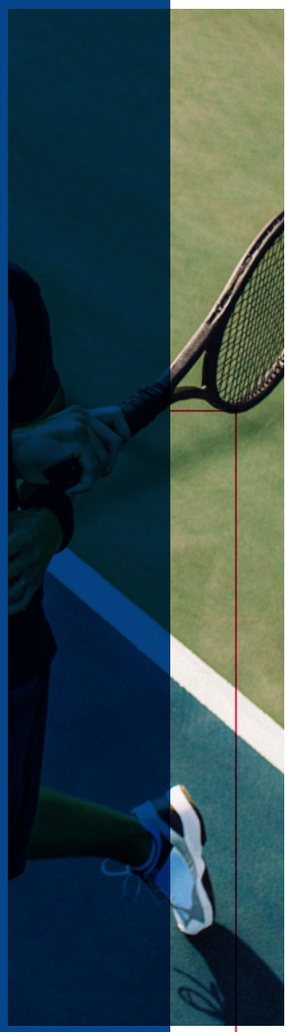
In the phase before exercise, the sensor glucose target range should be between 126-180 mg/dL in children and adolescents at moderate risk of hypoglycaemia and/or with moderate exercise and between 162-216 mg/dL with high risk of hypoglycaemia and/or intense exercise.

These targets can be achieved by reducing the preprandial insulin bolus by 25-75% or adjusting it to the type, duration and intensity of exercise. If sensor blood glucose is below these targets, a glucose intake of 10-15 g is recommended. Exercise can start on reaching 90 mg/dL or 126-180 mg/dL in children and adolescents at high risk of hypoglycaemia. Physical exercise is contraindicated when blood glucose is >270 mg/dL and ketone bodies are >1.5 mmol/L and a correction insulin dose should be administered.[3,20].

Monitor hypoglycaemia alerts are recommended at 100 mg/dL for hypoglycaemia and 180 mg/dL for hyperglycaemia or higher individually (Table 17)

Table 17: Actions to take according to IGM data before starting exercise in different groups of children and adolescents with T1D

<table>
<tr><th colspan="3">Glucemia en Sensor pre-ejercicio en diferentes grupos DM1 (mg/dl)</th><th>Flecha de tendencia</th><th colspan="2">Acción</th></tr>
<tr><td>HD intenso y/o Bajo riesgo hipoglucemia</td><td>HD moderado y/o Moderado riesgo hipoglucemia</td><td>HD bajo y/o alto riesgo hipoglucemia</td><td>Dirección</td><td>Aumento esperado de glucosa en sensor</td><td>Disminución esperada de glucosa en sensor</td></tr>
<tr><td colspan="3">>270 mg/dl y cetonemia >1,5 mmol/l</td><td>Cualquiera</td><td colspan="2">No ejercicio
Corrección con insulina[a]</td></tr>
<tr><td colspan="3">>270 mg/dl y cetonemia <1,5 mmol/l</td><td>Cualquiera</td><td>Considerar insulina correctora[a], Puede actividad leve/mod</td><td>Considerar insulina correctora[a], Puede cualquier AF</td></tr>
<tr><td>180-270</td><td>199-270</td><td>217-270</td><td>↗ ↑</td><td>Actividad leve/mod</td><td>Cualquier AF</td></tr>
<tr><td colspan="3"></td><td>→ ↘ ↓</td><td colspan="2">Cualquier AF</td></tr>
</table>



126-180	145-198	162-216	→ ↗ ↑ ↘ ↓	Cualquier AF 5g HC Cualquier AF	10g HC Cualquier AF
90-125	90-144	90-161	↗ ↑	Cualquier AF	5g HC Cualquier AF
			→	5g HC Cualquier AF	10g HC Cualquier AF
			↘	10g HC Cualquier AF	15g HC Cualquier AF
			↓	Cantidad individual HC Retrasar AF[b]	
	<90		Cantidad individual HC Retrasar AF[b]		

Adaptado de *"position statement EASD, ISPAD, ADA. 2020"*
a 50% del factor de corrección habitual con insulina cuando glucosa en sensor está próxima al límite superior
b Retrasar ejercicio hasta alcanzar al menos 90 mg/dl e idealmente 126-180 g/dl en aquellos con alto riesgo de hipoglucemia

HD: hábito deportivo; **AF:** actividad física **HC:** hidratos de carbono;

During exercise

The sensor target range during exercise is 80-180 mg/dL and preferably 126-180 mg. This range may be greater in children or adolescents with low EH or high risk of hypoglycaemia. CH consumption with blood glucose of 126, 145 or 162 mg/dL based on risk of hypoglycaemia rather than arrow trend has been shown to provide a greater reduction in hypoglycaemia among children and adolescents.

If sensor glucose is >270 mg/dL, ketone bodies should be measured and if >1.5 mmol/L, exercise should be stopped, the cause of the hyperglyceamia identified and correction insulin used (50% of the usual correction dose). After exercise, measurement of ketone bodies should be repeated to confirm that diabetic ketoacidosis has not developed.

In the case of glucose >270 mg/dL and ketone bodies >1.5 mmol/L, it is recommendable to do only aerobic exercise to avoid hyperglycaemia caused by the adrenal response to intense exercise.

Exercise should be stopped if sensor glucose level is <90 mg/dL, capillary blood glucose should be tested and CH provided. Exercise can be restarted if sensor glucose is >90 mg/dL and the trend arrow is horizontal or rising. Exercise must not be restarted if glucose is <54 mg/dL.[20] (Tabla 18)

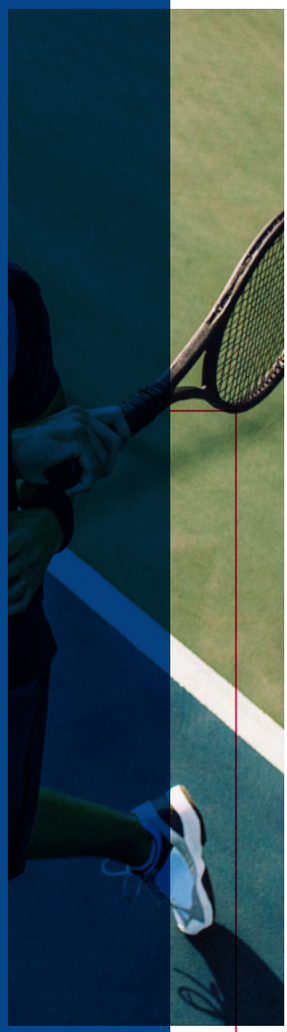
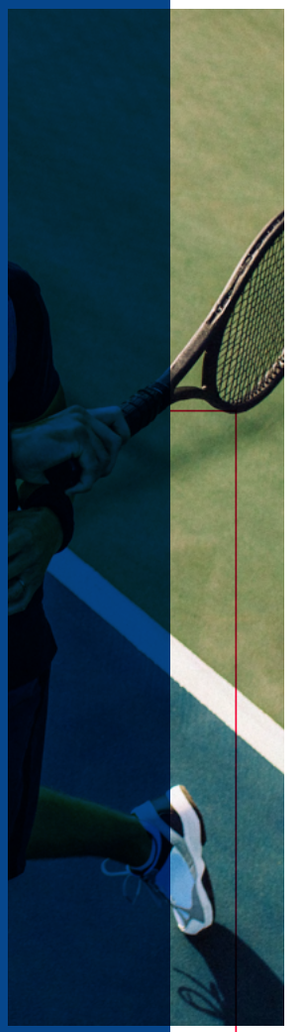


Table 18: Actions to take based on IGM during exercise in different groups of children and adolescents with T1D

Glucemia (mg/dl) durante ejercicio en diferentes tipos DM1			Flecha	Acción	
HD intenso y/o Bajo riesgo hipoglucemia	HD moderado y/o Moderado riesgo hipoglucemia	HD Bajo y/o alto riesgo hipoglucemia	Dirección	Aumento esperado de glucosa	Disminución esperada de glucosa
>270 mg/dl y cetonemia >1,5 mmol/l			Cualquiera	Detener ejercicio Considerar insulina correctora[a] No reiniciar ejercicio	
>270 mg/dl y cetonemia <1,5 mmol/l			↗ ↑	Considerar insulina correctora[a], Continuar cualquier AF	Continuar cualquier AF Considerar Actividad leve/mod
			→	Considerar insulina correctora[a], Continuar AF	Continuar cualquier AF
			↘ ↓	Continuar cualquier AF	
181-270	199-270	217-270	→ ↗ ↑	Continuar cualquier AF Considerar insulina correctora[a]	Continuar cualquier AF
			↘ ↓	Continuar cualquier AF	
126-180	145-198	162-216	Cualquiera	Continuar cualquier AF	
<126	<145	<162	↗ ↑	Continuar cualquier AF	
			→	5g HC Continuar Cualquier AF[b]	10g HC Continuar Cualquier AF[b]
			↘	10g HC Continuar AF[b]	15g HC Continuar Cualquier AF[b]
			↓	15g HC Continuar AF[b]	20g HC Continuar Cualquier AF[b]
	<70			Parar cualquier AF Considerar confirmar glucemia capilara Ingesta individualizada de HC Reiniciar cualquier AF posible[c,d]	
	<54			Parar cualquier AF Confirmar glucemia capilar Ingesta individualizada de HC No reiniciar ejercicio	

Adaptado de *"position statement EASD, ISPAD, ADA. 2020"*
a La elevación de cuerpos cetónicos debería confirmarse tras ejercicio. Si glucosa en sensor es >270 y c. cetónicos <1.5 mmol/l, sólo se recomienda ejercicio aeróbico
b 50% del factor de corrección habitual con insulina cuando glucosa en sensor está próxima al límite superior
c Reevaluar glucosa en sensor a los 30 min tras ingesta de carbohidratos
d Reiniciar ejercicio cuando glucosa en sensor >90 mg/dl y/o

HD: hábito deportivo; **AF:** actividad física; **HC:** hidratos de carbono



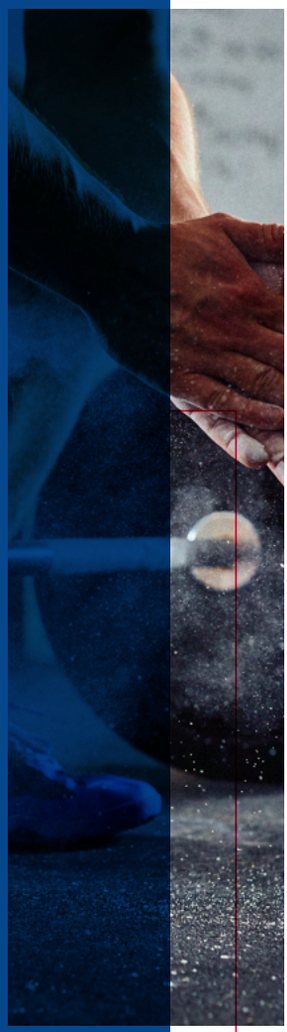
After exercise

Hypoglycaemia may occur several hours after exercise, especially when prolonged and moderate/high intensity.

After ending exercise (90 minutes post-exercise), the recommendable glucose range is 80-180 mg/dL or higher depending on the risk of hypoglycaemia. If sensor glucose levels rise rapidly, administering a correction insulin bolus (50% of usual correction dose) may be considered, except when close to bed time to avoid post-exercise nocturnal hypoglycaemia. In the case of glucose >80 mg/dL in children and adolescents at high risk of hypoglycaemia, CH should be ingested and repeated until glucose levels are reestablished.

RECOMENDACIONES 10

1. The insulin dose adjustment should be adapted to the intensity and duration of the exercise.
2. It is preferable to adapt the carbohydrate intake to the weight of the child/adolescent.
3. It is recommendable to establish hypo/hyperglycaemia alerts in ranges of 100-180 mg/dL or tailored to the individual and favour use of remote monitoring (e.g. mobile apps that permit remote real-time monitoring of the blood glucose sensor).



OTHER ASPECTS TO CONSIDER

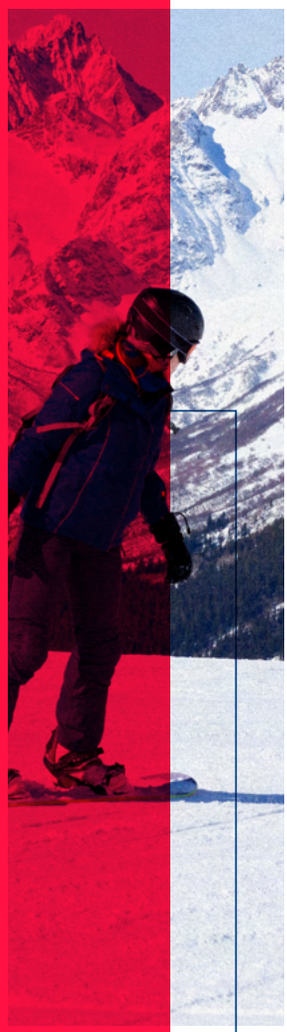
Injuries and glycaemic control

People with T1D have a greater hyperglycaemic response to injury (especially with prior hyperglycaemia and/or hypoinsulinaemia), related to a sharp rise in the secretion of stress hormones (ACTH, cortisol, growth hormone, catecholamines and glucagon). In addition, poor metabolic controls can be associated with greater risk of infection, poor healing of wounds and fractures. Athletes with diabetes should make an effort to maintain glucose levels close to normal.

Although no researcher has directly approached the topic of glycaemic control and insulin therapy for common athletic injuries (e.g. sprains and muscle strains), the commonly recommended guidelines for non-critical patients can be applied to injured athletes with diabetes.[85]

Associations for sport with diabetes

In Spain there is at least one association for athletes with diabetes (the Spanish Association for Sport with Diabetes: AEDD (in its Spanish abbreviation), a cultural and sporting organisation whose aim is to promote all kinds of sporting activity in order to help all patients with diabetes manage and control their disease, incorporating sport into their therapy. (http://team-one.es).



CONFLICT OF INTEREST

None of the authors has reported relevant conflicts of interest in writing this article. The final version of the document has been approved by all the authors. All the authors have contributed equally in drawing up the recommendations.

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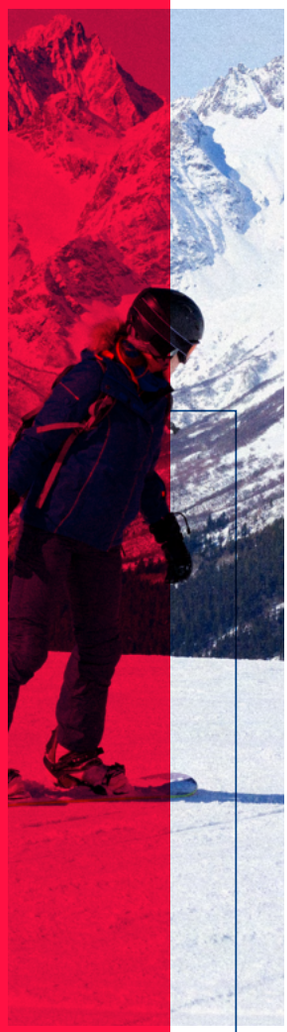

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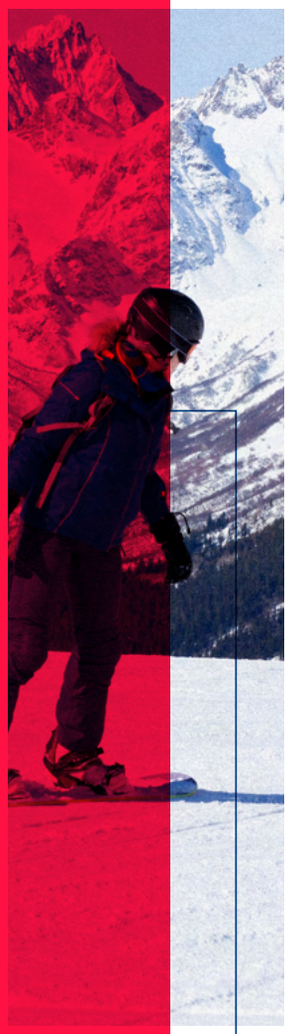

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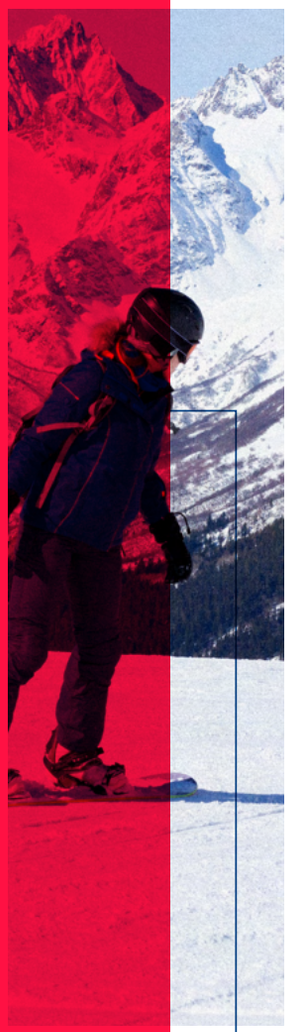

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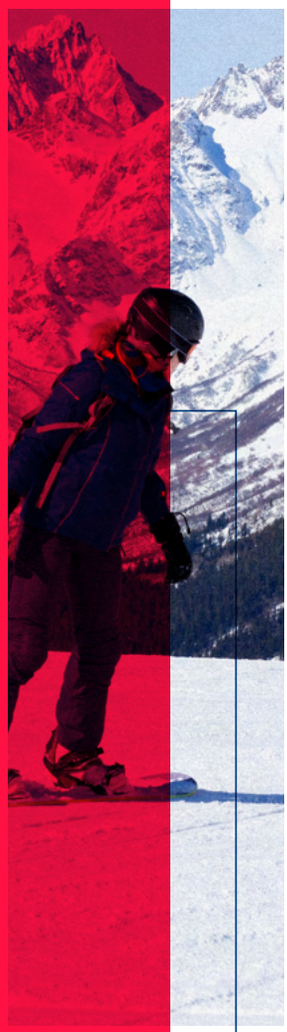

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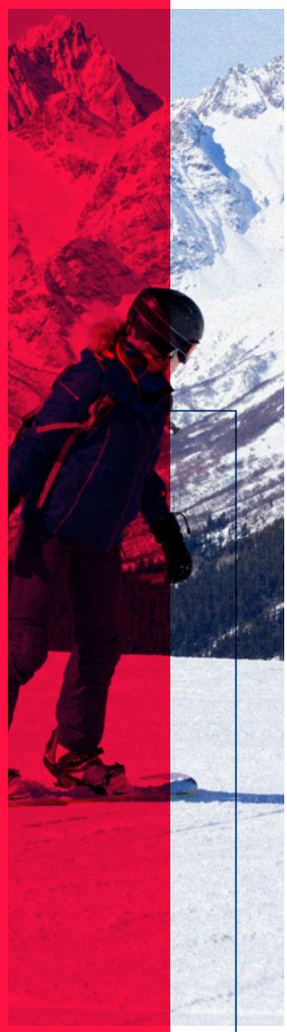

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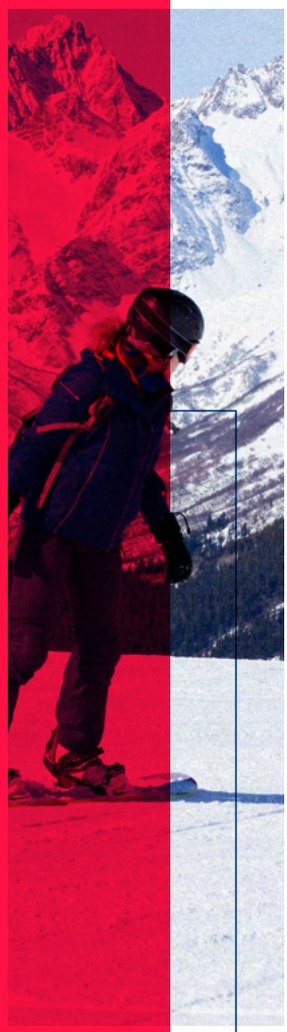

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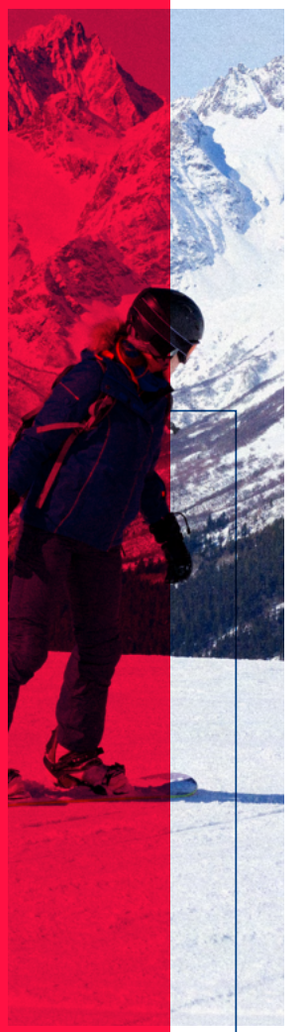

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