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CONSENSUS DOCUMENT

Executive summary of the consensus statement of: Clinical recommendations for sport practice in people with diabetes (RECORD Guide). Update 2021. Diabetes Mellitus Area of the Spanish Society of Endocrinology and Nutrition (SEEN)

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KEYWORDS
Diabetes mellitus;
Sport;
Insulin;
Physical activity

Abstract
Objective: To guide professionals involved in the care of people with diabetes mellitus who practice sport.
Participants: Members of the Diabetes Mellitus Working Group of the Spanish Society of Endocrinology and Nutrition.

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Methods: A group of experts in each area covered by the statement carried out a bibliographic review of the available evidence for each topic, based on which recommendations were subsequently agreed upon within the Diabetes Mellitus Working Group.
Conclusions: The statement provides practical recommendations for the management of diabetes mellitus during sports practice.

PALABRAS CLAVE
Diabetes mellitus;
Deporte;
Insulina;
Actividad física

Resumen ejecutivo del documento de consenso sobre: recomendaciones clínicas para la práctica del deporte en personas con diabetes mellitus (Guía RECORD). Actualización 2021. Área de Conocimiento de Diabetes Mellitus de la Sociedad Española de Endocrinología y Nutrición (SEEN)

Resumen
Objetivo: Orientar a los profesionales involucrados en la asistencia de personas con diabetes mellitus que realizan deporte.
Participantes: Miembros del Grupo de Trabajo de Diabetes Mellitus de la Sociedad Española de Endocrinología y Nutrición.
Métodos: Un grupo de expertos en cada área del documento realizó una revisión bibliográfica de la evidencia disponible para cada tema, en base a las cuales se establecieron unas recomendaciones posteriormente consensuadas dentro del Grupo de Trabajo de Diabetes Mellitus.
Conclusiones: El documento aporta cuestiones prácticas para el manejo de la diabetes mellitus durante la práctica deportiva.

Introduction

In 2015, the Grupo de Trabajo de Diabetes Mellitus (GTDM) [Diabetes Mellitus Working Group] of the Sociedad Española de Endocrinología y Nutrición (SEEN) [Spanish Society of Endocrinology and Nutrition] (GTDM-SEEN) prepared its C̈linical recommendations for the practice of sport by people with diabetes mellitus (RECORD Guide)¨,[1] to offer guidance for professionals involved in the care of people with DM who do sport.

With the appearance of new drugs, continuous glucose monitoring (CGM) systems, and new publications in this field, these recommendations have been updated.

The complete document to which this executive summary corresponds can be consulted at:

https://www.seen.es/ModulGEX/workspace/publico/modulos/web/docs/apartados/2814/270122_032340_8130974046.pdf.

Methodology

Within the GTDM-SEEN, a group of experts was selected who carried out a bibliographic review of the available evidence for each topic with an inclusion date until 31 September 2020.

Given the practical absence of clinical studies related to most of the aspects reviewed, it was not possible to establish recommendations based on the level of evidence. Therefore, it was decided to formulate ''expert recommendations'' based on the available data discussed jointly by the Working Group and have subsequently been endorsed by the SEEN Board of Directors.

Effects on glycaemic control of different types of exercise

Exercise increases muscle glucose uptake by improving insulin sensitivity (IS) in an insulin-independent manner. These effects differ according to the type of DM.[2]

The intensity of aerobic exercise is usually defined by the consumption of O_2 by the muscles In practice, the percentage of maximum heart rate (MHR) can be used. The intensity is mild if the %MHR is <40-50%, moderate if it is 50–70% and high if it is >70—80%.

Recommendations 1

- Diabetes mellitus type 2 (DM2)
  - o Both aerobic and resistance exercise improve IS and HbA1c. These benefits are enhanced by the combination of both, as well as by greater intensity and regularity in the practice of exercise.
  - o A training plan based on high intensity interval training (HIIT) achieves similar benefits with a significant reduction in the time invested.
- Diabetes mellitus type 1 (DM1)
  - o The short-term effect on blood glucose depends mainly on insulin levels and the type of exercise.

- There is insufficient evidence to conclude that regular exercise consistently improves HbA1c levels in adults with DM1. Despite this, it should be recommended due to its other benefits on the cardiovascular system.
- In overweight or obese people, exercise guidelines based on HIIT improve HbA1c levels if adherence is adequate.

Pre-exercise medical evaluation

People with DM should undergo an assessment before starting an exercise programme[3] that will include the following points:

- Setting some goals:
  - Finding out if the patient has any associated disease or complication.
  - Planning and scheduling exercise.
  - Preventing injuries.
- Reviewing the diabetes care plan (glycaemic control, therapy, education, etc.).
- Pre-exercise medical examination.[4]
- Formulation of specific recommendations (Table 1).[5]
- Special examinations (stress test, spirometry, ECG).
- Assessment of sport habit (SH) and risk of hypoglycaemia.

People with DM who do sport should be classified according to SH in[6]:

- intense SH: >2 weekly exercise sessions lasting ≥45 min.
- Moderate SH: 1—2 weekly exercise sessions lasting ≥45 min.
- Low SH: does not exercise regularly.

They should also be classified according to their risk of hypoglycaemia when interstitial glucose monitoring (IGM) is available, according to time below range (TBR) less than 70 mg/dl, in:

- *Low risk of hypoglycaemia:* preserved recognition of hypoglycaemia and TBR < 4% in the last three months
- *Moderate risk of hypoglycaemia:* conserved recognition of hypoglycaemia and TBR 4–8% in the last three months.
- *High risk of hypoglycaemia:* inadvertent hypoglycaemia or severe hypoglycaemia in the last six months and/or TBR > 8% in the last three months.

Recommendations 2

- People with DM with possible cardiovascular (CV) disease or microvascular complications who wish to engage in more vigorous exercise than brisk walking should undergo a medical evaluation that will include medical history, a physical examination (including fundus examination, foot examination and neuropathy test), resting ECG and possibly a stress test.
- The stress test should be performed in all patients at high CV risk.
- A stress test is useful in multiple ways:
  - For exercise prescription.
  - For risk stratification.
  - For detecting silent coronary disease.
  - For detecting abnormal hypertensive responses.
- It is recommended to classify people according to their SH and risk of hypoglycaemia.

Modifications to be made in the diet

The recommended balance of macronutrients is 45–65% carbohydrates (CH), 20–35% fats and 10–35% proteins[2], although it should be personalised. Ensure the intake of B vitamins, iron, calcium and vitamin D. They should only be supplemented if there are deficits in the diet or if they are found to be lacking.[7]

Before, during and after exercise, adjustments will be made according to Table 2. In prolonged exercise or recovery, slowly absorbed CH (sCH) reduces the risk of hypoglycaemia and avoids hyperglycaemic peaks.

In exercise longer than one hour, isotonic drinks can prevent hypoglycaemia and contribute to ion replenishment; soft drinks and energy drinks should be avoided. Milk drinks are useful for recovery and prevention of late hypoglycaemia.[8]

After finishing exercise, if blood glucose is less than 120 mg/dl, without IGM data, it is advisable to ingest 15—20 g sCH, both in DM1 and DM2 treated with insulin or secretagogues.

Competitive athletes should ensure glycogen replenishment by taking 1–1.5 g/kg CH in the first two hours after exercise. Hyperglycaemia associated with explosive exercises should be monitored. If post-exercise CH intake is insufficient, taking them with protein may be beneficial. After strenuous or prolonged exercise, a night-time snack with fat, CG and protein can prevent nocturnal hypoglycaemia.

Recommendations 3

- There is no ideal recommendation for macronutrients. The recommended macronutrient balance is 45–65% CH, 20–35% fats and 10–35% proteins.
- Before exercise, capillary blood glucose should be checked. If it is less than 100 mg/dl (without IGM data), a CH supplement should be taken if receiving treatment with insulin or secretagogues.
- An adequate state of hydration should be maintained during exercise. If exercise lasts more than one hour, between 30—60 g of CH per hour should be ingested.
- After exercise, CH replenishment should be ensured, preferably with those with a low glycaemic index.

Glucose monitoring

The EASD-ISPAD-ADA position on the use of CGM and flash glucose monitoring during exercise[6] suggests doing the following when taking exercise:

- Pre-exercise preparation:

Table 1 Exercise and diabetes complications.

Complication	Recommendations	Contraindications	Precautions
Cardiovascular disease	Low-impact aerobic activities: walking, cycling, swimming, treadmill.	Recent AMI (<6 weeks). Hypertensive activities: lifting heavy weights, high-intensity workouts	Increase heart rate gradually
Autonomic neuropathy	Low-intensity exercises that do not change blood pressure: aquatic activities, stationary cycling and sitting exercises	High intensity. Sudden changes in body position.	Test to check for coronary disease. Maintain BP to prevent orthostatism. Avoid exercising in very cold or very hot environments and maintain adequate hydration. Monitor blood glucose.
Peripheral neuropathy	Swimming, cycling, chair exercises, arm exercises and exercises that do not require the use of the feet.	Very demanding long walks, running, and any activity that involves jumping. Do not exercise if with ulcers or active Charcot foot.	Pre-exercise evaluation of sensitivity. Suitable footwear. Daily hygiene check of the feet.
Diabetic retinopathy	Low-intensity aerobic exercises: stationary bike, walking, swimming, treadmill	Do not perform physical activity in the presence of active PDR (vitreous haemorrhage, vitreomacular traction) and after recent photocoagulation or surgery. Avoid exercises that increase BP abruptly (violent physical activities, Valsalva, weights), those that involve sudden movements or lowering the head (gymnastics, yoga) and contact sports (boxing, martial arts, etc.)	Gradual increase in intensity. Avoid allowing systolic BP to reach >170 mmHg during exercise.
Diabetic nephropathy	Low-intensity aerobic activities	Avoid exercises that increase BP abruptly: violent physical activities, Valsalva manoeuvre, lifting weights.	Pay particular attention to hydration and BP control.

AMI: acute myocardial infarction; BP: blood pressure; PDR: proliferative diabetic retinopathy.

  - Set the hypoglycaemia alarm at the highest level allowed during peak exercise and the hyperglycaemia alarm above 180 md/dl to avoid alarm fatigue.
- During exercise:
  - Maintain a time in the range of 90—180 mg/dl (126—180 mg/dl in the case of prolonged aerobic exercise).
- After exercise:
  - Time in range of 80—180 mg/dl for the first 90 min after performing the exercise.
  - Perform CGM every 15—30 min after doing exercise for the first 90 min after finishing.
  - Modify the hypoglycaemia alarm based on the risk of mild, moderate or severe hypoglycaemia.

Recommendations 4

- CGM and lash glucose monitoring devices constitute *therapeutic support* when exercising.
- It is recommended to analyse sensor data during physical activity and retrospectively to:
  - Modify the insulin dose.
  - Adapt the intake of CH.
  - Minimise late hypoglycaemia.
- If hypoglycaemia in interstitial blood is detected during exercise, testing with capillary blood is recommended.
- The manufacturer's recommendations for use should be followed.
- There are no conclusive data regarding altitude, depth or contact sports, although it seems that they could be useful in types of exercise such as diving and high-altitude sports.

Insulin therapeutic strategy (injectable)

The intensity, duration and type of exercise, and the corresponding individual metabolic response to it, must be predetermined to consider specific adjustments of the

Table 2 CH supplementation before, during and after practising sport for people with DM1 with glucose monitoring.

	SH type and/or hypoglycaemia risk			Trend arrow	Action	
Pre-exercise	Intense SH and/or low risk of hypoglycaemia	Moderate SH and/or moderate risk of hypoglycaemia[a]	Low SH and/or high risk of hypoglycaemia[b]	Direction	Rise in blood glucose expected	Fall in blood glucose expected
	126–180 mg/dl	145–198 mg/dl	162–216 mg/d	↗↑	Start exercise	
				→		
				↘↓	Start exercise	Start exercise +15 g GL
	90–125 mg/dl	90–144 mg/dl	90–161 mg/dl	↗↑	Start exercise	Start exercise +15 g GL
				→	Start exercise +10 g GL	Start exercise +20 g GL
				↘	Delay exercise[c] +15 g GL	Delay exercise[c] +25 g GL
				↓	Delay exercise[c] +20 g GL	Delay exercise[c] +30 g GL
		70–89 mg/dl		↑	Start exercise +10 g GL	Delay exercise[c] +20 g GL
				↗	Delay exercise[d] +15 g GL	Delay exercise[c] +25 g GL
				→	Delay exercise[d] +20 g GL	Delay exercise[c] +30 g GL
				↘	Delay exercise[d] +25 g GL	Delay exercise[c] +35 g GL
				↓	Delay exercise[d] + personalised GL	Delay exercise[c] + personalised GL
		<70 mg/dl		Delay exercise[e] + personalised GL		
Exercise	<126 mg/dl	<145 mg/d	<162 mg/dl	↗↑	Continue exercise	
				→	Continue exercise[h] +10 g GL	Continue exercise[h] +15 g GL
				↘	Continue exercise[h] +15 g GL	Continue exercise[h] +25 g GL
				↓	Continue exercise[h] +20 g GL	Continue exercise[h] +35 g GL
		<70 mg/dl		Any trend	Personalised GL replenishment	
Post exercise	<80 mg/dl	<90 mg/dl	<100 mg/dl	↗↑	No	
				→	+10 g GL	
				↘	+15 g GL	
				↓	Individualised intake	

GL: rapidly absorbed glucose/carbohydrates; CH: carbohydrates; SH: sport habit.

[f] Includes older people with functional status and preserved higher functions.

[g] Includes older people with impairment of ≥2 instrumental activities of daily living or mild-moderate cognitive impairment.

[i] Check blood glucose at 30 min, repeat GL administration if necessary.

[a] Includes older people with functional status and preserved higher functions.

[b] Includes older people with impairment of ≥2 instrumental activities of daily living or mild-moderate cognitive impairment.

[c] Delay exercise until reaching at least 90 mg/dl and trend arrow ↗, ↑, or →.

[d] Delay exercise until reaching at least 70–89 mg/dl and trend arrow.

[e] Delay exercise until reaching at least 70–89 mg/dl and trend arrow ↑ if a rise in blood glucose is expected during exercise or delay exercise until reaching 90 mg/dl and ↗, ↑, or → if a fall in blood glucose is expected blood glucose during exercise.

[h] Check the sensor at least 30 min after GL intake and repeat GL intake if necessary.

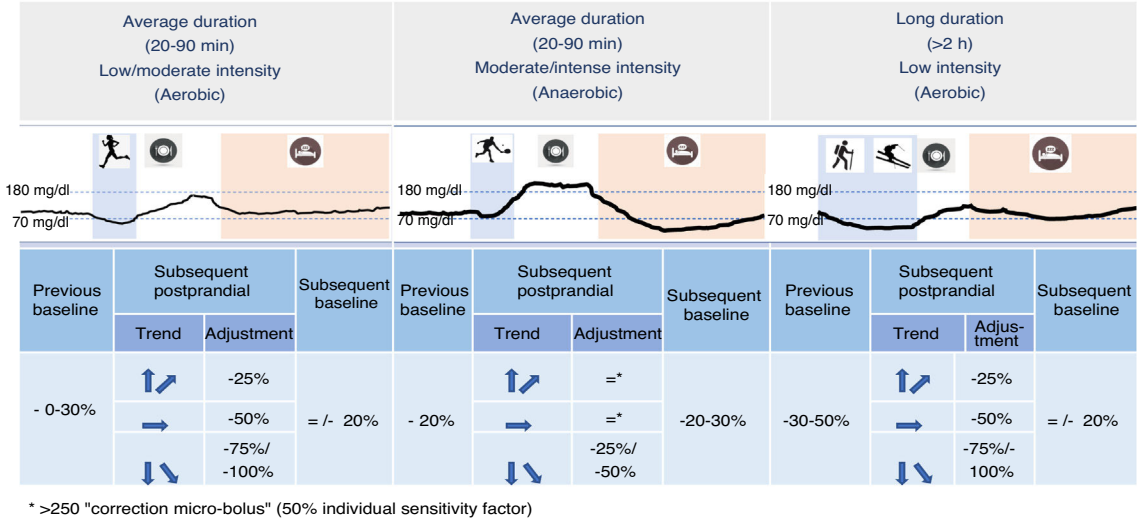

Figure 1 Recommendations for basal/intermediate insulin adjustment (excluding degludec*) and rapid preprandial post-exercise (1–3 h) in three exercise modalities.

insulin dose.[2] The increasingly widespread use of CGM makes it possible to take into account the current glucose levels and the prediction of their trend in the following hours when making these decisions (Fig. 1).

Recommendations 5

Aerobic exercise

- Reduce basal (except degludec)/intermediate insulin before that day by at least 20% (glycaemic target: 126—160 mg/dl, depending on risk).
  - o If exercise is done on an empty stomach or post-absorptive period (>3 h after ingestion), consider making greater reductions.
- Adjust rapid-acting insulin.
  - o Preprandial insulin *before exercise* (1—3 h before): reduce by at least 25% for the exercise of short duration (<1/2 h), 50% for the medium duration (<1 h), and 75% for prolonged exercise (>1 h).
  - o Preprandial insulin *before exercise* (1—3 h after): consider a reduction of at least 25% for the exercise of short duration (<1/2 h), 50% for the medium duration (<1 h) and 75% for prolonged exercise (>1 h).
  - o For corrective boluses for hyperglycaemia peaks: only in cases of clearly high blood glucose levels (>250 mg/dl) consider adding a ''corrector micro-bolus'' (50% of the individual correction factor).[5]

Anaerobic exercise

- Reduce basal (except degludec)/intermediate post-exercise insulin by 20—30%
- Rapid-acting insulin.
  - o Preprandial insulin before exercise (between 1 and 3 h before) and preprandial insulin after exercise (1–3 h after): do not reduce.
  - o For correction boluses for hyperglycaemia peaks (generally of short duration): only in clearly elevated blood glucose levels (>250 mg/dl) consider adding a ''correction micro-bolus'' (50% of the individual correction factor).[3]

Adjustment of non-insulin drugs

In general, it is not necessary to modify the regimen of non-insulin drugs for sporadic exercise, but secretagogue drugs and SGLT2 inhibitors should be reduced or discontinued when intense and long-lasting exercise is performed.

Recommendations 6

- Hypoglycaemia is the most common metabolic complication in patients with diabetes who perform physical exercise, although, in the absence of insulin treatment, it appears infrequently.
- The non-insulin drugs with the greatest risk of hypoglycaemia are those that increase endogenous insulin secretion (sulfonylureas and glinides), although the overall risk is usually low.
- Although SGLT2 inhibitors do not cause hypoglycaemia, they predispose to a higher risk of dehydration, hypotension and ketosis/ketoacidosis.
- Before intense and long-lasting exercise (>60 min), it is recommended to reduce the usual dose or suspend the administration of both sulfonylureas/glinides and SGLT2 inhibitors.

People with DM on continuous subcutaneous insulin infusion (CSII)

The following considerations should be taken into account:

- Choose the place of insertion of the catheter avoiding areas where it can receive blows or cause rubbing or friction.

Table 3 Recommended basal rate adjustments and CH supplements in CSII or CSII/CGM users before planned and unplanned exercise.

Planned exercise			
CBG/IG 60—90 min pre-exercise	BR reduction (temporary) 60—90 min before exercise	CBG/IG at start of exercise	CH intake 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 half calculated bolus
>150 mg/dl	20—30%	>150 mg/dl	Not necessary
Unplanned exercise			
CBG/GI pre-exercise	BR reduction (temporary)	CBG/IG at start of exercise	CH intake 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

CBG: capillary blood glucose; IG: interstitial glucose; CH: carbohydrates; CSII: continuous subcutaneous insulin infusion; CGM: continuous glucose monitoring; BR: basal rate.

- In general, it is not recommended to turn off the CSII, but it may be necessary for some sports (aquatic, contact, etc).
- In the event of disconnection (try not to exceed 1—2 h), previously administer a bolus equivalent to the basal rate (BR) x 1.25, applying a reduction of 20–50%. In disconnections >3—4 h, administer the calculated dose by injecting a short- or intermediate-acting insulin (regular, NPH or detemir) 30—60 min before disconnection, applying the same reduction percentage. When reconnecting, a correction bolus ≈50% of the calculated dose may be required to avoid subsequent hyperglycaemia.
- In high-risk or high-intensity sports, it is recommended to increase the predictive stop threshold of CSII + CGM (80 mg/dl) and keep it until 90 min after completion of the activity.
- For BR and bolus adjustments, see Tables 3 and 4.[2]

Recommendations 7

- In planned exercise, use a temporary BR with a reduction percentage before starting the exercise. If the activity is going to be carried out in 2—3 h following the administration of a bolus, it is advisable to reduce the bolus.
- Use a temporary BR with a reduction percentage in unplanned exercise and take a CH supplement.
- After finishing the exercise, the temporary BR can be cancelled when the value of capillary blood glucose (CBG) or interstitial glucose (IG) is >100—120 mg/dl. In some sports, it may be necessary to disconnect from the CSII.
- In high-intensity exercise, a correction bolus may be required when reconnecting.
- If a CGM system is used, frequently check the IG value and trend.
- With the CSII + CGM integrated system with predictive stop, it is recommended to raise the stop threshold when doing high-intensity exercise. With the hybrid closed-loop system, it is recommended to use the safe BR.

Table 4 Recommended prandial bolus settings in CSII or CSII/CGM users before planned exercise within 2–3 h.

Type of planned exercise 2—3 hours after prandial bolus		
Low-moderate intensity aerobic exercise	Low-moderate intensity anaerobic exercise	Intense anaerobic exercise
Reduce 25% if low intensity	May not require adjustment; evaluate —25% to —50% depending on glucose change expected from previous experiences	Does not require adjustment
Reduce from 50% to -75% if moderate intensity		Consider adding small correction if CBG/IG elevated

CBG: capillary blood glucose; IG: interstitial glucose; CSII: continuous subcutaneous insulin infusion; CGM: continuous glucose monitoring.

Training guidelines for physical exercise

Training for people with DM has dual aspects which must go in parallel: on the one hand, the physical training incorporates and increases physical fitness, and on the other, the training is supported by structured diabetes education to minimise the risk of dysglycaemia.

Table 5 Assessments to be made before, during and after training.

ASSESSMENTS to BE MADE (BEFORE, DURING and AFTER) TRAINING

WARM UP | DURING TRAINING (workloads) | COOL DOWN AND STRETCHING

----- ASSESSMENTS TO MAKE BEFORE TRAINING ----------

(I) REVIEW the GENERAL LIST of **SITUATIONS WHEN NOT TO EXERCISE**

(II) REVIEW the DM-DEPENDENT VARIABLES, to clarify any contraindications for training or individual risk of hypoglycaemia

- IF THERE IS TREATMENT WITH INSULIN OR SECRETAGOGUES OR if there is variability and intrinsic tendency to hypoglycaemia (and if these are perceived correctly)
- IF THERE ARE COMPLICATIONS/CO-MORBIDITIES THAT CONTRAINDICATE ANY TYPE OF EXERCISE
- Review the essential VARIABLES FOR CH /INSULIN ADJUSTMENTS: MEASURE BLOOD GLUCOSE (BASAL BLOOD GLUCOSE), TIME SINCE LAST INTAKE AND AMOUNT OF CIRCULATING INSULIN.

(III) REVIEW the EXERCISE-DEPENDENT VARIABLES that CAN INDUCE CHANGES IN BLOOD GLUCOSE during training. IOS

- TYPE OF EXERCISE: AEROBIC, MIXED, ANAEROBIC
- INTENSITY AND DURATION of EXERCISE

(IV) REVIEW the PHYSICAL CONDITION of the person with DM, to set the starting point for training (duration and intensity of training).

INITIAL DECISION-MAKING (from BEFORE TRAINING)
(quantity of CH/modifications in INSULIN DOSE/administration times]

ASSESS performing SPRINTS +/- CAFFEINE (5-6 mg/kg) BEFORE core training to minimise hypoglycaemia.

---------- **ASSESSMENTS to be made DURING TRAINING** -----

(I) CHECK the INTENSITY and type of exercise during training. With each change in intensity and duration, the glycaemic response should be re-analysed and adjustments re-calculated if necessary.[2,3]

(II) MONITOR BLOOD GLUCOSE PERIODICALLY. (Every 1 h if it is low intensity; every 20-30 min if it is moderate or high intensity)

(III) START TRAINING in SESSIONS of LOW INTENSITY and SHORT DURATION. First, increase the training frequency, then the time/volume, and lastly the intensity.

DECISION-MAKING (to be carried out DURING TRAINING)
(essentially adjust CH intake)

✓ As training progresses: glycaemic response needs to be re-analysed and adjustments recalculated if necessary.

---------- **ASSESSMENTS to make at the END of the TRAINING** ---

- **MONITORING OF BLOOD GLUCOSE AFTER TRAINING** (early and late),
- **FINAL DECISION-MAKING FOR AFTER TRAINING:** amount of CH/changes in INSULIN DOSE/administration times
- **ANALYSE RESULTING BLOOD GLUCOSE DURING and AFTER TRAINING WITH ADJUSTMENTS MADE at** start of and during training
- **RECALCULATE NEEDS IF NECESSARY IN NEXT TRAINING SESSION**

It is a planned and complex process that organises progressive and increasing workloads that stimulate the development of different physical capacities. The glycaemic response to exercise depends on variables related to DM and factors related to exercise and has a marked individual response.[2,8] The recommended adjustment ranges are also very wide.

Table 5 shows the recommendations to be followed before, during and after training.

Table 6 Recommendations for treatment with insulin and carbohydrates for exercise in children and adolescents with DM1.

Treatment	Type/intensity of exercise Duration up to 30—45 min	Type/intensity of exercise Duration >45 min
MDI/CSII: Preprandial bolus	−25% light exercise −50% moderate exercise −50% intense aerobic exercise −25% mixed aerobic/anaerobic exercise Up to −50% post-exercise	−50% light exercise −75% moderate exercise −75% intense aerobic exercise −50% mixed aerobic/anaerobic exercise Up to −50% post-exercise
MDI Basal insulin[a]	−20% in afternoon/evening exercise	−20% in afternoon/evening exercise −30—50% unusual activity[a]
CSII	Up to −50% 90 min pre-exercise Pump suspension (<60 min) −20% overnight post-exercise[b]	Up to −80% 90 min pre-exercise Pump suspension (<60 min) −20% overnight post-exercise[b]
CH intake[c]	−10—15 g CH −1.5 g CH/kg weight/hour in intense exercise −0.4 g CH/kg weight before bed if evening exercise	

CH: carbohydrates; CSII: continuous subcutaneous insulin infusion; MDI: multiple doses of insulin.
Adapted from Moser et al.[6].
[a] The basal insulin dose should be reduced the day before and on the day of exercise, except when degludec is used.
[b] Basal insulin should be reduced by 20% before bedtime if exercising in the afternoon/evening, depending on the duration and intensity of exercise, except when degludec is used.

Recommendations 8

- Before, during and after training, a series of assessments should be made to make adjustments (Table 5).
- Training should be started in low-intensity and short-duration sessions and then *progress gradually*.
- Training that *combines aerobic and strength exercises* should be carried out every other day.
- Whenever possible, they should be accompanied (but not replaced) by *flexibility exercises*. In older adults with DM, combine flexibility and balance training 2—3 times a week.
- Whenever possible, increase unstructured physical activity between workouts, as it provides extra benefits in terms of health.[5]

Peculiarities of specific sports

The special characteristics of each sport can influence the practical management of people with DM.

Diving can be practised safely by patients with DM as long as a series of conditions are followed, and various guides deal with this aspect.[9] Cases have been published on the effective use of IGM during repetitive dives. To prevent decompression sickness, good hydration is very important, and it would be advisable for subjects with DM to readjust their dive computers to more conservative safety limits.

There are no data that contraindicate mountaineering for people with well-controlled DM. Some aspects should be taken into account:

- Glycaemic control: insulin needs and blood glucose levels increase (possibly due to the effect of counterregulatory hormones), so reducing the dose of insulin or oral drugs is not recommended.
- Retinopathy: can worsen at altitude.
- Thyroid function: there is a greater demand for thyroid activity at altitude, so prior thyroid dysfunction must be ruled out and treated if present (even subclinical).
- IGM: can be reliable up to an altitude of 3600 m.
- *Practical aspects*. Insulin should be prevented from freezing by storing it in bags attached to the body. Use nasal glucagon (it does not freeze and is properly stored at temperatures up to 30°).

Recommendations 9

- *Divers*: start with a blood glucose level ≥180 mg/dl. With any suspicious sign of hypoglycaemia: alert your diving partner and abort the dive. Dive only within the recommended safety margins for patients with DM. Dive with a partner who is informed and trained in managing hypoglycaemia.
- *Mountaineers*: do not reduce the dose of drugs; keep well hydrated; protect against the cold, especially the feet; and check blood glucose frequently. Keep insulin and glucagon from freezing. No increased risk of altitude sickness. Acetazolamide not recommended in DM1.
- *Long-distance runners*: preventive reduction of hypoglycaemic doses. Adequate hydration. Supplements and self-monitoring (or IGM) schedules. Prevent heat stroke.
- *Navigators*: do not go sailing alone. Supplements and self-monitoring (or MIG) every hour.
- *Swimmers*: start with a blood glucose level ≥180 mg/dl. If hypoglycaemia is suspected, stop exercising, take supplements (carry gels in your swimsuit) and get out of the water.

Exercise for adolescents with type 1 diabetes

Tables 6 and 7 provide recommendations for treatment with insulin and CH before and during exercise in children and

Table 7 Actions to adopt according to IGM data in different groups of children and adolescents with DM1.

	SH type and/or risk of hypoglycaemia			Trend arrow	Action	
Pre-exercise	Intense SH and/or low-risk hypoglycaemia	Moderate SH and/or moderate risk of hypoglycaemia	Low SH and/or high risk of hypoglycaemia	Direction	Rise in blood glucose expected	Fall in blood glucose expected
	>270 mg/dl and ketonemia >1.5 mmol/l			Any	No exercise	Correction with insulin[a]
	>270 mg/dl and ketonemia <1.5 mmol/l			Any	Consider correction insulin[a] Can do mild/mod activity	Consider correction insulin[a] Can do any PA
	180–270 mg/dl	199–270 mg/dl	217–270 mg/dl	↗↑	Mild/mod activity	Any PA
				→↘↓		Any PA
	126–180 mg/dl	145–198 mg/dl	162–216 mg/d	→↗↑		Any PA
				↘↓	5 g CH Any PA	10 g CH Any PA
				↑↗	Any PA	5 g CH Any PA
	90–125 mg/dl	90–144 mg/dl	90–161 mg/dl	→	5 g CH Any PA	10 g CH Any PA
				↘	10 g CH Delay PA[b]	15 g CH Delay PA[b]
				↓	Individual CH amount	Delay PA[b]
	<90 mg/dl			Individual CH amount		Delay PA[b]
During exercise	>270 mg/dl and ketonemia >1.5 mmol/l			Any	Stop exercise Consider correction insulin[a] Do not restart exercise	
				↗↑	Consider correction insulin[c] Continue PA	Continue any PA Consider mild/mod activity
	>270 mg/dl and ketonemia <1.5 mmol/l			→	Consider correction insulin[c] Continue PA	Continue any PA

Table 7 (*Continued*)

SH type and/or risk of hypoglycaemia			Trend arrow	Action	
			↘↓	Continue any PA	
181—270 mg/dl	199—270 mg/dl	217—270 mg/dl	↗↑→	Continue any PA Consider correction insulin[c]	Continue any PA
			↘↓	Continue any PA	
126—180 mg/dl	145—198 mg/dl	162—216 mg/d	Any	Continue any PA	
<126 mg/dl	<145 mg/dl	<162 mg/dl	↗↑	Continue any PA	
			→	5 g CH Continue any PA[d]	10 g CH Continue any PA[d]
			↘	10 g CH Continue PA[d]	15 g CH Continue PA[d]
			↓	15 g CH Continue PA[d]	20 g CH Continue PA[d]
<70 mg/dl			Stop any PA Consider confirming capillary blood glucose[c] Individualised intake of CH Restart any possible PA[e,f]		
<54 mg/dl			Stop any PA Confirm capillary blood glucose Individualised intake of CH Do not restart exercise		

PA: physical activity; CH: carbohydrates; SH: sport habit.
Adapted from Moser et al.[6].

[a] 50% of usual correction factor with insulin when sensor glucose is near the upper limit.
[b] Delay exercise until reaching at least 90 mg/dl and ideally 126—180 mg/dl in those at high risk of hypoglycaemia.
[c] Elevation of ketone bodies should be confirmed after exercise. If sensor glucose is >270 mg/dl and ketones <1.5 mmol/l, only aerobic exercise is recommended.
[d] 50% of usual correction factor with insulin when sensor glucose is near the upper limit.
[e] Re-monitor sensor glucose 30 min after CH intake.
[f] Restart exercise when sensor glucose >90 mg/dl and/or trend arrows ↗↑.

adolescents with DM1 adapted to the ESAD, ISADP and ADA recommendations.[6]

After finishing exercise (90 min post-exercise), the recommended glucose range is 80—180 mg/dl or higher, depending on the risk of hypoglycaemia. If sensor glucose levels rise rapidly, a correction bolus of insulin (50% of the usual correction dose) may be considered, except around bedtime, to avoid post-exercise nocturnal hypoglycaemia. In the case of glucose <80 mg/dl in children and adolescents at high risk of hypoglycaemia, CH will be ingested and consumption will be repeated until glucose levels are restored.

Recommendations 10

- The insulin dose should be adapted to the intensity and duration of the exercise.
- It is preferable to adapt the intake of carbohydrates to the weight of the adolescent/child.
- It is recommended to set hypo/hyperglycaemia alerts in ranges of 100—180 mg/dl or to do it individually and favour remote monitoring (for example, mobile applications that allow remote monitoring of the blood glucose sensor in real-time).

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