



ABCD position statement on physical activity and exercise in diabetes

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Background

Physical activity and exercise are important components of lifestyle changes in the treatment of people with type 2 diabetes (T2DM).¹ By contrast, exercise in type 1 diabetes (T1DM) may add to the burden of dysglycaemia. The mechanism by which regular physical activity may lead to these benefits has become better understood.² The benefits and risks of exercising in T1DM and T2DM are different and an understanding of these differences is fundamental whilst advising patients with diabetes.

During any moderate to strenuous physical activity the whole body consumption of oxygen increases to supply the oxygen demands of muscles. The energy requirement is derived from different sources depending upon the type, duration and intensity of exercise. To ensure that the central nervous system continues to get a constant source of glucose, during exercise, the blood glucose levels are maintained at a near constant level in healthy individuals.³ This equation of supply and demand during exercise is no different in people who have diabetes.

Adjustments in metabolism geared to maintain blood glucose are mostly mediated predominantly through hormonal changes. These changes include a fall in circulating plasma insulin and a rise in glucagon and circulating catecholamines. These hormonal changes play an important role in maintaining a glucose milieu which supplies the blood glucose to the brain and also to the exercising muscles.⁴ However, these hormonal adjustments in response to exercise are impaired or

ABSTRACT

The Association of British Clinical Diabetologists (ABCD) recognises the key importance of exercise and physical activity in the management of diabetes. This position statement by the ABCD aims to help health professionals working in diabetes to familiarise themselves with the issues surrounding the management of type 1 and type 2 diabetes.

ABCD strongly supports that exercise and physical activity are key components of the initial and ongoing management of type 2 diabetes and can help to improve metabolic control and tackle cardiovascular risk factors. ABCD also believes that diabetes teams have an important role both in promotion of physical activity and in education of the key benefits to patients, carers and health professionals involved in the day to day management of this condition. ABCD also recognises that the issues in type 1 diabetes are very different and that, in this category of patients, the health benefits of exercise are not well documented – the issue is to help and support people to engage in physical activity or sports of their choice in a safe manner. This kind of support is not universally available at present and much needs to be done to achieve this. Copyright © 2010 John Wiley & Sons. *Practical Diabetes Int* 2010; 27(4): 158–163

KEY WORDS

exercise; physical activity; sports; type 1 diabetes; type 2 diabetes; ABCD

absent in T1DM. During exercise, patients with T1DM are dependent upon exogenous insulin; the consequence of having too little insulin in the circulation is that they will generally have an excessive release of counter-regulatory hormone which may increase already high levels of plasma glucose and even production of ketone bodies.⁵ By contrast, if the circulating insulin levels are high, this can lead to increased utilisation of glucose and other metabolites in response to exercise with precipitously falling plasma glucose and hence clinical hypoglycaemia may evolve. These concerns are similar in patients with T2DM who are treated with insulin, although it is perceived to be less of a problem in patients with T2DM.

The main aim of this ABCD position statement is to provide clear guidance to health care professionals on the current thinking regarding the role of physical activity in the

management of T2DM, including prevention of T2DM. In addition, ABCD is keen that accurate advice is available to clinicians on the various complex issues facing patients with T1DM who take part in regular strenuous physical activity or competitive sports.

Exercise and physical activity in type 2 diabetes

Benefits of regular physical activity in type 2 diabetes

Regular moderate intensity physical activity improves short- and long-term glycaemic control with increased hepatic and peripheral insulin sensitivity. This is not surprising as the exercising muscles use 7–20 times more glucose than non-exercising muscles.⁶ The long-term improvement in glycaemic control is likely to be due to the cumulative effect of repeated bouts of physical activity. It is also suggested that the improvement in fasting plasma glucose may be of

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larger magnitude in those on diet or oral hypoglycaemic agents than in those treated with insulin.⁷ These results indicate that the best time to promote physical activity in subjects with T2DM is around the time of diagnosis, a time when motivation for behaviour change is also generally at its highest in most subjects (Table 1).

Increased physical activity in diabetes may enable reduction, or even discontinuation, of pharmacological treatment in a substantial proportion of patients.^{8,9} Regular physical activity has been shown to be of benefit in promoting weight loss when used in conjunction with diet and may also help to maintain weight loss in the long term.^{9,10}

A meta-analysis of the effects of exercise on glycaemic control and body weight concluded that exercise reduces HbA_{1c} by approximately 0.66%, an amount which may be clinically significant in the long run, although this was not associated with weight loss in the exercise group nor mediated by differences in weight, exercise intensity and the volume of exercise.¹¹ Therefore, the beneficial effects of exercise on glucose are not solely mediated through reduction in weight, or intensity and volume of exercise.

Similarly, in a meta-analysis of 25 studies looking at the effects of physical activity on blood pressure, there was an average reduction of 11 and 8mmHg respectively in systolic and diastolic blood pressures. This magnitude of blood pressure reduction may be particularly useful in those with mild hypertension and in early stages of the disease.¹²

Risks of physical activity

Sports injuries

Whether subjects with diabetes taking physical activity and engaging in exercise and sport are more prone to musculo-skeletal injuries when compared to non-diabetic subjects is unknown. It is reported that subjects with diabetes are prone to stress fracture of the lower extremities which may be due to the presence of neuropathy, vascular disease, and associated low bone density. Upper extremity injuries may also be more common in subjects with diabetes. This may be due to a higher

prevalence of peri-arthritis of shoulder joints in subjects with diabetes than in those without (10.8% *vs* 2.3%). These problems are frequently bilateral and are unrelated to neuropathy.¹³

Musculo-skeletal injuries are related to duration and intensity of physical activity. These may result from chronic, repetitive and high impact injuries rather than actual trauma. However, it is important that these risks are discussed with the patient and appropriate steps taken to avoid these. This can be achieved by setting realistic exercise training goals and by limiting the intensity and duration of any sustained activity, particularly during exercise initiation. Proper footwear and proper surroundings are also vital to minimise these risks.¹⁴

Hypoglycaemia

The risk of hypoglycaemia with exercise is greatest in T1DM, but is also seen in patients with T2DM who are treated with sulphonylureas or insulin. Hypoglycaemia may occur during or soon after physical activity or it may be delayed for up to 24 hours following a single bout of exercise.¹⁵ Hypoglycaemia is not an issue in those on diet alone or in those taking metformin (Table 2). Physical activity can also potentially cause transient or prolonged hyperglycaemia in T2DM following extremely strenuous physical activity, but generally in those who are insulin deficient and have poor control of diabetes.¹⁶ Various strategies to reduce the risk of hypoglycaemia during and following exercise are reported and are summarised in Tables 2–5.¹⁷

Macrovascular complications

Worsening of pre-existing cardiovascular disease or unmasking of previously asymptomatic coronary heart disease remains a major concern. Up to 20% of newly diagnosed subjects with T2DM may already have asymptomatic coronary artery disease (CAD).^{18,19} Sudden death due to acute myocardial infarction, arrhythmias or intracerebral bleed is much dreaded but exceedingly rare, with a documented incidence of 0–2/1 000 000 hours of exercise.^{19,20} This risk is only slightly increased in those with pre-existing heart disease.^{20,21}

Table 1. Rationale for promoting physical activity in type 2 diabetes

- As an adjunct to diet for initial weight loss
- Aid to help maintain the weight loss
- Loss of and redistribution of abdominal fat
- Favourable effect on glycaemic control
- Adjunct for the management of hypertension in diabetes
- Management of dyslipidaemia
- Improvement in general and mental wellbeing

Microvascular complications

Retinopathy. There is no evidence that moderate intensity physical activity has a detrimental effect on non-proliferative retinopathy, and the risk in patients with proliferative retinopathy is low.^{21,22} However, it is prudent to avoid vigorous physical activity which involves pounding, repeated jarring, weight lifting, high impact aerobics, and activities which involve the Valsalva manoeuvre if there is proliferative retinopathy or vitreous haemorrhage. Those with known retinopathy need to have regular retinal review depending on the severity of retinopathy.^{14,22} (Table 6.)

Nephropathy. Exercise is known to increase albuminuria during and in the period immediately after exercise, although the long-term implications for diabetic nephropathy are unclear.^{23,24} Exercise capacity is often limited in subjects with overt nephropathy *per se* or due to concomitant autonomic neuropathy.^{25,26} There seems to be no good reason to restrict low to moderate intensity exercise in these subjects, although they should be discouraged from high intensity strenuous physical activity. Those patients with nephropathy who are already on renal dialysis will have reduced exercise capacity. In addition, a majority will have co-existing cardiac involvement. Careful attention needs to be given to adjust physical activity programmes to their complications and disabilities to help maintain their functional status. (Table 6.)

Neuropathy. Patients should be screened for peripheral neuropathy, foot deformity or degenerative joint



disease to avoid injury, and adequate advice about foot care should be provided. Those who have significant neuropathy and insensitve feet are more prone to foot ulceration and also fractures so that weight bearing exercises such as step exercises and prolonged jogging/walking or treadmill should be undertaken with care or avoided. Sensory involvement with Charcot arthropathy or foot ulcers is generally considered to be an absolute contraindication for weight bearing exercises. Non-weight bearing exercises such as cycling, swimming, rowing and arm exercises are more appropriate in these circumstances. (Table 6.)

Subjects who have autonomic neuropathy may have a decreased capacity for exercise, especially high intensity exercise, due to their inadequate cardiovascular response to exercise. These subjects may be more prone to episodes of extreme hypo- or hypertension following vigorous exercise.²⁵ Postural hypotension may be aggravated and they may be at risk of excess fluid loss through sweating which may be relevant in hot climates. Recently, it has been suggested that these subjects may also be prone to silent myocardial ischaemia.²⁶ Exercise in these individuals needs to be gentle and is perhaps better limited to sessions of short duration.

Strategies to increase exercise uptake in people with diabetes

The benefits of exercise are considered to outweigh the risks associated with it,²² which can be minimised or avoided through individualisation of physical activity programmes by selecting patients through a proper clinical evaluation. The problem is how to get people to do more exercise. It seems reasonable to tell those who take no regular physical activity that some physical activity is better than none (Table 7). People wishing to increase physical activity should be instructed to start with relatively low intensity exercise and build up gradually as physical conditioning to exercise occurs. Patients should also be informed to limit the duration of exercise at the outset and report immediately any untoward symptoms.

Certain tasks can be considered advantageous, prior to starting regular

Table 2. Guidance on the need to take extra carbohydrate (CHO) in relation to medical treatment

Medicine	Effect on glucose	Extra CHO with exercise
Metformin	No effect on glucose with exercise	No
Sulphonylureas	Promote hypoglycaemia with effort; may need to reduce dose before planned exercise	Check glucose with exercise and take extra CHO during exercise
Rosiglitazone/pioglitazone	No effect on blood glucose; increases exercise capacity and duration	No
Acarbose	No effect on glucose with exercise	No
Gliptins/GLP1 agonists	Unknown; need studies	Unknown; need studies

Table 3. Advantages and disadvantages of various strategies to reduce hypoglycaemia during exercise in diabetes

Strategy	Advantages	Disadvantages
Reducing pre-exercise bolus insulin	Reduces hypoglycaemia during and following exercise; reduces carbohydrate requirement	Needs pre-planning; not helpful for spontaneous exercise or for late post-prandial exercise
Reducing pre-exercise basal insulin	As above	As above; causes pre- and late post-exercise hyperglycaemia
Taking extra carbohydrate with exercise	Useful for unplanned or prolonged exercise	May not be possible with some exercises; not helpful where weight control important; easy to over-replace causing hyperglycaemia
Pre- or post-sprint exercise burst	Reduces hypoglycaemia during and following sports	Effect limited to shorter and less intense exercise
Insulin pump therapy	Offers flexibility and rapid change in insulin infusion rates post-exercise	Expensive; may not be practical for contact sports (e.g. rugby/football/judo)
Reducing basal insulin post-exercise	Reduces nocturnal hypoglycaemia	May cause morning hyperglycaemia

physical activity or tackling any competitive sport. This can be summarised under the ABCDE acronym: Assessment and clinical evaluation of patient prior to exercise, Behaviour modification, Continuing support, Decision making and Encouragement.

ABCD suggests that every patient who wishes to start strenuous physical activity should have a thorough and careful medical history and physical examination. This should include symptoms and signs of disease itself (metabolic control), assessment of

**Table 4.** Planning for safe participation in exercise and sports

Metabolic control <ul style="list-style-type: none">• It is generally safe to start exercise if blood glucose levels are between 7–12mmol• Avoid/delay activity if pre-exercise levels are >12mmol and urine shows ketones• Ingest added carbohydrate (about 30g) if glucose levels are <7.0mmol
Glucose monitoring (before, during and after activity) <ul style="list-style-type: none">• Check glucose before, every 30 minutes during and after exercise• Helps identify when changes in insulin or food intake are necessary• Helps learn the impact of different exercises and conditions on blood glucose
Food and fluid Intake <ul style="list-style-type: none">• Consume added carbohydrate as needed to avoid hypoglycaemia and maintain energy levels needed for exercise• Carbohydrate-based foods should be available during and after exercise
General safety tips <ul style="list-style-type: none">• Avoid exercising alone and going into remote areas• Let others know that you are going out exercising and when you are expected back

both macrovascular and microvascular complications, and evaluation of the peripheral and autonomic nervous system.

Cardiovascular examination clearly is of paramount importance because of physiological changes which this system has to undergo to deliver emergency supplies to the body during exercise; we feel that all patients who are about to undertake moderate to high intensity physical activity should have a complete cardiovascular assessment which should include baseline ECG. However, in the presence of any additional risk factors for CAD, appearance of microvascular complications or any evidence of peripheral vascular disease one may wish to consider a formal exercise tolerance test to check the cardiac reserves. Nevertheless, if a patient is planning to take a low intensity exercise, it remains a matter of clinical judgement as to whether the patient should be subjected to formal exercise testing. Patients who have pre-existing CAD should have a formal assessment of responses to exercise prior to undertaking any activity.

Similarly, peripheral arterial disease should be assessed based on history and physical examination. If there is any suggestion that the blood supply to both feet is compromised, formal Doppler pressure measurements should be undertaken.

General principles for starting and preparing for exercise

- A period of proper warm up and cool down at low intensity level for 5–10 minutes.
- The following precautions should be undertaken by all individuals with diabetes taking exercise:
 - Appropriate foot wear, including proper midsoles and socks to avoid blisters.
 - Keep feet dry and avoid trauma, and inspect feet before and after activity.
 - Wear a diabetes identification bracelet.
 - Adequate hydration prior to and during exercise. Fluid should be taken regularly during exercise to avoid dehydration.
 - Carry a bum bag with blood testing kit, hypo stop, contact numbers, mobile phone etc in case of emergency.

Exercise in prevention of type 2 diabetes

The prevalence of diabetes is increasing at a fast rate in most countries worldwide, to an epidemic proportion. T2DM has a number of disease characteristics which makes it potentially a preventable disease.²⁷ In most subjects at risk of T2DM, there is generally a long but variable period during which a minor degree of glucose intolerance exists. These abnormalities can be

Table 5. Strategies needed to prevent hypoglycaemia during exercise and sports

<ul style="list-style-type: none">• Insulin dose adjustments• Timing of exercise in relation to last insulin injection and meal• Carbohydrate (CHO) supplementations and diet<ul style="list-style-type: none">– General principles– Understand general dietary requirements– Learning how to calculate CHO needed during exercise– Type and method of CHO supplementation• Integration of 10-second maximal sprint

recognised by performing an oral glucose tolerance test (known as impaired glucose tolerance, IGT), or by measuring fasting plasma glucose (known as impaired fasting glucose, IFG).

Subjects with IGT or IFG are at a higher risk of future diabetes compared to those whose glucose tolerance is normal. These risk factors for diabetes are potentially modifiable.²⁸ As in T2DM, insulin resistance and defective insulin secretion contribute to the development of IGT and IFG. Both of these defects can be modified through lifestyle interventions and/or pharmacological therapies.²⁹

Studies have been consistent in showing a protective effect of physical activity on the occurrence of T2DM and suggested a causative role for physical inactivity in T2DM. The results of published randomised trials, which have used lifestyle intervention, including physical activity, have shown that T2DM can be prevented and such interventions are cost effective. (Table 8.)^{30–35} Implementing the findings of these studies to the general population is the immediate challenge.

Intervention trials' conclusions and recommendations

Conclusions and recommendations from the intervention trials to prevent diabetes are:

- Only moderate intensity and duration of activity are needed to be effective in preventing diabetes.
- Weight loss seen in the intervention group needs to be moderate but needs to be maintained over a longer period of time.



Table 6. Recommendations regarding physical activity in patients who present with complications of diabetes

Retinopathy	Nephropathy	Peripheral arterial disease	Neuropathy
No DR or NPDR: poses no restrictions	No nephropathy, micro- or macroalbuminuria: generally no restriction; dictated by medical assessment	No history of IC and normal Doppler flow, and no clinical evidence of blood flow problems; no restriction should apply	No neuropathy: generally means most activities can be performed safely without any restriction
Moderate to severe NPDR: activities which are likely to increase systolic blood pressure should be avoided, but activities such as walking, swimming and low impact aerobics should be allowed	Overt nephropathy, dialysis etc: exercise capacity is generally reduced; many patients will have concomitant cardiovascular problems. There is no reason to avoid low or moderate intensity physical activity but high intensity or strenuous physical activity is best avoided	In the presence of symptoms of IC, Doppler evidence of PVD, or ischaemic changes: low to moderate intensity exercise, with careful supervision of feet, appropriate foot wear	The presence of loss of sensation and significant neuropathy should be an indication to avoid weight bearing exercises as repeated exercise can invariably lead to foot ulceration; these patients should avoid prolonged walking, treadmill and jogging
PDR and patients undergoing laser for PDR: as above	–	–	Activities such as arm exercises, swimming and bicycling are allowed

DR: diabetic retinopathy; IC: intermittent claudication; NPDR: non-proliferative diabetic retinopathy; PDR: proliferative diabetic retinopathy; PVD: peripheral vascular disease.

- There is accompanying benefit on cardiovascular risk factors such as blood pressure and dyslipidaemia.
- At present there are no data as to whether studies used in this way, to reduce or delay the onset of T2DM, will impact on mortality in the long run.

Exercise and physical activity in type 1 diabetes

Most activities which include varying intensity of physical activity can be performed by most people with T1DM who have optimum metabolic control of diabetes and have no complications. The most important issue in these individuals is understanding the impact of exercise on blood glucose control and developing knowledge and skills to avoid hypo- and hyperglycaemia.³⁶ Therefore, they need to learn how to change their insulin administrations and carbohydrate intake prior to, during and after exercise.³⁷ High performance in individuals who take part in competitive sports is another important issue and they need adequate support and advice to achieve this. It has now been recognised that patients themselves

play a crucial role in collecting useful information on self-monitoring of blood glucose when they exercise, and they need the help of experts to interpret these data to help them improve their performance during exercise and competitive sport.³⁸

Hypoglycaemia

Hypoglycaemia can occur during, immediately after and several hours after, and can be avoided. Patients need to utilise their skills and what they learnt from previous experimentation, and adjust their insulin and carbohydrate intake appropriately. It is unacceptable to stick to any rigid recommendations, but each athlete or individual needs to find out exactly what works for them in different conditions under which they usually exercise.³⁹ However, certain general guidelines and principles need to be followed⁴⁰ (Tables 1–7 summarise this).

Exercising in special situations

Special sports and activities

The American Diabetes Association Position Statement asserts that: ‘All levels of exercise, including leisure

Table 7. How much physical activity do we need?

- Three to five times/week, spaced at no more than 48-hour intervals
- Mild to moderate intensity (aerobic and/or resistance training)
- 15–60 mins per session, with warm up and cool down period of approximately 5 mins
- Brisk walking, jogging or running, swimming, bicycling, tennis, badminton skiing, dancing etc

activities, recreational sports, and competitive professional performance, can be performed by people with T1DM who do not have complications and are in good blood glucose control.’ The vast majority of sports are open to individuals with T1DM and impose no restrictions.

Some extreme forms of sport pose a bigger challenge for individuals with diabetes and at present there are still outright bans on sports such as bobsleigh, flying, horse racing, motor racing and paragliding in insulin treated individuals. There is also a ban for boxing, although ABCD believes that this should be allowed

**Table 8.** Intervention studies to reduce incidence of type 2 diabetes^{30–35}

Study	No of subjects	Characteristics of subjects	Mean duration (yrs)	Intervention	Incidence of diabetes (% pa)	% reduction in incidence
Diabetes Prevention Programme (USA) ³⁰	3234	IGT	2.8	Control Lifestyle* Metformin	11.0 4.8 7.8	– 58 31
Diabetes Prevention Study (Finland) ³¹	522	IGT	3.2	Control Lifestyle [†]	7.8 3.2	– 58
Da Qing IGT and Diabetes Study (China) ³²	577	IGT	6	Control Diet [‡] Exercise [#] Diet & exercise	13.3 8.3 5.1 6.8	– 33 47 –
STOP-NIDDM Acarbose Study (multinational) ³³	1429	IGT	3.3	Placebo Acarbose	12.7 9.7	– 25
TRIPOD (USA) ³⁴	236	Previous GDM	2.5	Placebo Troglitazone	12.1 5.4	– 55
Diabetes Prevention Programme (India) ³⁵	531	IGT	2.5	Control Lifestyle* Metformin Lifestyle + met	55 38.3 40.5 39.5	– 28.5 26.4 28.2

IGT: impaired glucose tolerance; GDM: gestational diabetes mellitus. *At least 7% weight loss and 150 mins of physical exercise activity per week. [†]At least 5% weight loss and 210 mins of physical exercise activity per week. [‡]Target BMI of 23. [#]Increase in exercise by at least 1 unit per day (e.g. extra 30 mins of slow walking or 5 mins of swimming).

given appropriate medical assessment, monitoring and supervision. Some restrictions apply also for ballooning, gliding, motorcycle racing, parachuting, power boat racing, and rowing. Health professionals need to be aware of these restrictions. Diving is also permitted with restrictions, but health professionals need to specifically advise on the issues of hypoglycaemia and its management. If there is any doubt, further information is available from Diabetes UK and the self-governing body for individual sports and these can be contacted.

Exercise in elderly people

Regular physical activity even at advanced age can help prevent decline in strength and muscle mass. The decrease in insulin sensitivity is also related to lack of physical activity. Studies have also shown that regular exercise has beneficial metabolic effects and also adherence levels are as good in this population as seen in the general population and with

acceptable levels of complications. It is therefore likely that this population would benefit from better levels of fitness and activity and improved health outcomes and wellbeing.

Conclusions

The recent White paper by the Health Minister about their strategic plans to increase the physical activity of the population as a whole is to be commended.⁴¹ However, these population-based solutions are mostly of benefit as preventative strategies for chronic diseases and cardiovascular risk.

In people who already have diabetes, health professionals will have to play a pivotal role in promotion of physical activity and in making sure that it continues to be a part of management strategy to improve metabolic control and associated cardiovascular disease risk factors. In addition, the bigger challenge is to make sure that individuals have the information, knowledge and skills to engage in safe activities. ABCD

believes that physical activity, its benefits and other related information should be a vital part of any educational tools currently being used to educate patients with T1DM and T2DM. ABCD also recognises that the benefits of exercise and activity in T2DM in improving metabolic control are greatest when it is used in the early stages of disease process, i.e. at and around the time of diagnosis when motivation for change is also at its highest for a given individual.⁸

For people with T1DM the emphasis remains on adjusting therapeutic regimens to allow safe participation in activities in all patients, but especially in the younger age group where diabetes can be a barrier for active participation in sports.

Conflict of interest statement

There are no conflicts of interest.

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References are available at www.practicaldiabetesinternational.com.



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