

Exercise in Adult Patients with Type 2 Diabetes: Integrated Diabetes and Endocrine Academy Consensus Statement for Indian Patients

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Abstract

Exercise is one of the pillars of diabetes management. Current guidelines provide a general recommendation regarding exercise advice for patients with diabetes, but guidance regarding exercise suited for Indian patients is scarce. We aim to arrive at exercise recommendations for patients with type 2 diabetes incorporating the latest modalities of exercise along with consideration of Indian patients. We conducted an extensive search using the PubMed electronic database and Google Scholar until February 1, 2024. The retrieved literature was then meticulously deliberated upon by the panel members to arrive at appropriate recommendations. The various guidelines and literature recovered have advised exercise regimes for type 2 diabetes, but have not always covered all the aspects of exercise, including timing of exercise, exercising in the presence of associated comorbidities such as diabetic foot, neuropathy, retinopathy, cardiovascular disease, elderly, and pregnancy with diabetes in one complete recommendation. Furthermore, advice regarding soleus exercise has not been incorporated in any recommendation. Moreover, advice specifically for Indian patients with type 2 diabetes was lacking. This recommendation incorporates the latest in exercise modalities for patients with type 2 diabetes, including patients with major macrovascular and microvascular problems, with specific advice for each complication which will serve as a guide for physicians when they advise patients regarding exercise.

Keywords: Diabetes, exercise, recommendation

INTRODUCTION

Exercise plays an integral part in the treatment of type 2 diabetes mellitus (T2DM). Despite this, majority of the patients in India do not engage in physical activity as per current international recommendations and, in general, have been found to have a more sedentary lifestyle compared to white Caucasians.^[1-3] Unsurprisingly, there is an inverse relation between the prevalence of dysglycaemia and higher quartiles of physical activity with 16.8%, 13.2%, and 11% prevalence of T2DM and impaired glucose tolerance amongst sedentary, moderately heavy, and heavy workers in South India.^[3] However, there is a dearth of detailed and exhaustive guidelines for Asian patients in general and Indian patients in particular. The aim of this consensus statement is to create

clear recommendations to guide physicians regarding exercise advice to patients with T2DM.

METHODS

A systematic literature search was made in the database of PubMed until February 1 2024, using key words and

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MeSH terms using Boolean “AND.” The various keywords included (“exercise” OR “physical activity”) AND (“Type 2 diabetes mellitus”) AND (“randomised controlled trials”) OR (“observational studies”) OR (“meta-analyses”) OR (“consensus statements”) AND (“Indians”). The inclusion criteria for articles included all the studies that assessed the impact of exercise and physical activity on T2DM and its complications. We excluded editorials, unpublished articles, case reports, and anecdotal reports. Hard and soft copies of all the relevant articles were retrieved and circulated among the panel members which consisted of fourteen experienced clinicians who are pioneers in their fields consisting of endocrinologists, physicians, diabetologists, and physical medicine consultants. After initial web-based meetings, one physical meeting was conducted during the 11th Integrated Diabetes and Endocrine Academy [IDEA] Congress [IDEACON] held on June 30, 2022, in Kolkata, India. The draft was then circulated among the panel members for revision and re-revision to arrive at a consensus on the following points regarding exercise advice in patients with T2DM:

- a. Benefits of exercise
- b. Types of exercise
- c. Timing of exercise
- d. Exercise considerations for those on oral antihyperglycaemic agents (OHA)
- e. Exercise considerations for those on insulin
- f. Pregnancy with diabetes
- g. Elderly
- h. Ischemic heart disease (IHD)
- i. Retinopathy
- j. Neuropathy
- k. Diabetic foot ulcer
- l. Arthritis.

BENEFITS OF EXERCISE

Exercise impacts metabolic parameters (reduction of weight by 1.1 kg, waist circumference by 3.2 cm, visceral adipose tissue by 30–40 cm², systolic blood pressure by 8–12 mmHg, diastolic blood pressure by 5–6 mmHg, HbA1c by 0.67%, and low-density lipoprotein by 3.87 mg/dl).^[4-14] Exercise improves insulin sensitivity as early as 48 h, with the effect persisting beyond 72 h.^[15] A greater drop in HbA1c has been observed with an increase in the intensity of exercise.^[4] However, the benefits of exercise begin to fade within 48–96 h of stopping exercise, necessitating a continual exercise program.^[5]

In addition to the traditional exercise regimes, the benefits of yoga are evident from a meta-analysis involving studies from across the world.^[6] Yoga can lower systolic blood pressure by 5.8 mm Hg, diastolic blood pressure by 4.12 mm Hg, heart rate by 6.5 beats per minute, and HbA1c by 0.45%, apart from a salutary effect on lipid profile.^[6] Apart from the metabolic benefits, yoga also reduces perceived stress, lowers catecholamine levels, improves mood, and reduces cardiovascular response to stress.^[7] Multiple trials in patients

with T2DM in India, including randomized controlled trials, demonstrated the beneficial effects of yoga on glycemic, anthropometric, and lipid parameters apart from improvement in autonomic function.^[16-20]

TYPES OF EXERCISE

Of the various modalities of exercise, aerobic exercise is more convenient and accessible. However, in older adults, resistance exercise may increase lean mass.^[21,22] Although all the modalities of exercise have a beneficial impact on glycemia and insulin sensitivity, combined aerobic and resistance exercises are superior to either modality alone.^[21,23] The four basic exercise types are as follows:

- a. Aerobic: Continuous rhythmic movements of large muscle groups (walking, cycling, jogging, swimming)
- b. Resistance: Using added weight to one’s body (push-ups, pull-ups, rowing, weight lifting)
- c. Flexibility: Increasing the full range of movement (lower back, hamstring stretching exercises)
- d. Balancing: Yoga, tai chi, standing on one leg, toe walking, walking sideways, walking backward.

Intensity of exercise

Patients may choose the intensity of exercise, depending on their physical health and availability of resources, but there should be a gradual progression as initially benefit can also be obtained from lower exercise volumes and intensities.^[23] Over a longer period, the duration and weekly frequency of exercise sessions more than exercise type or intensity affects glycemic control.^[24]

The intensity of exercise can be divided into the following groups:^[21,23,25]

- a. Low intensity: Able to whistle while exercising (slow walking)
- b. Moderate intensity: Able to hold conversation but not have the breath to whistle (brisk walking)
- c. High intensity: Breathing too heavily to comfortably speak in sentences (running, rowing, cycling)
- d. High-intensity interval exercise: Intermittent aerobic training with recovery periods

Flexibility exercises

Flexibility exercises improve joint range of motion in patients with T2DM.^[23] Adhesive capsulitis, or frozen shoulder, is a disabling condition, found in up to 32% of Indian patients with T2DM.^[26] Simple aerobic exercise involving movement of the shoulder joint may help to prevent this condition [Figure 1]. 5–10 min flexibility exercise at the end of aerobic and resistance exercise sessions is desirable.^[23]

Balance exercises

Simple at-home balance exercises may reduce the risk of falls without changes in leg strength.^[21,23] Standing on one foot, walking on toes or heel, walking backward, and walking sideways are examples of balance training.

Soleus push-up exercise

In this modern era, a vast number of patients are forced to sit for long hours. Soleus push-up (SPU) [Figure 2] may lead to a lowering of blood glucose.^[27] Unlike the major muscles involved in walking and running, 88% of the soleus muscle is type 1 slow twitch fiber which consumes glucose from the blood more effectively without fatigue as the metabolism avoids the anaerobic route.^[27] In a unique experiment, SPU was continuously used for 4 h, resulting in 52% less glucose excursion than when they were sitting still.^[27]

Recommendation 1: General recommendation regarding exercise for adults with T2DM

- Moderate-intensity exercise of 150 min weekly spread over at least 3 days/week with no more than 2 consecutive days without activity. For younger and physically fit individuals, shorter duration (minimum 75 min/week) of high intensity may be sufficient
- Resistance exercise at least twice a week is recommended for muscle strengthening
- A combination of moderate-intensity and high-intensity exercise has a better effect than either modality alone
- If chronic conditions/disability do not allow moderate-/high-intensity exercise, then they should engage in as much as physical activity as their abilities and conditions allow
- Small “doses” of physical activity during waking hours are recommended to modestly attenuate postprandial glucose (PPG) and insulin levels (for example: light intensity walking for 3 min for every 30 min prolonged sitting)
- Flexibility exercises 2–3 times/week are recommended to improve the range of movement and prevent disabilities like frozen shoulder
- Balance training 2–3 times/week is also recommended, especially in older adults

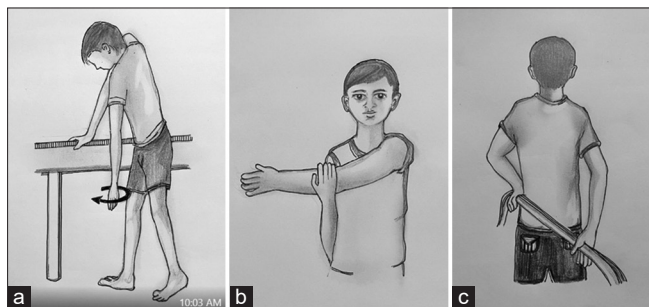


Figure 1: Examples of easy to do flexibility exercises to prevent/treat frozen shoulder, (a) Pendulum stretch, Support one arm on a table. Move the other arm in a tiny arc. (b) Cross body reach, Raise one arm with the other arm and bring it upwards and take it across the body. (c) Towel stretch, Hold one part of a towel and drape it over the shoulder. Hold the other end with the other hand and pull the towel to and fro

TIMING OF EXERCISE – WHEN IS THE RIGHT TIME TO EXERCISE – FASTING STATE OR AFTER FOOD INTAKE?

The impact of exercise intervention on the glycemic and lipemic responses to meal could depend on the time sequence of implementation.^[28] This assumes further importance in Asians and Indians, as they have greater PPG excursions than Caucasians.^[28] Even among Asians, Indians have higher postprandial insulin excursions as compared to Chinese and Malays, even when adjusting for body fat percentage or waist circumference.^[29]

Exercising in the fasted state more effectively attenuates the lipaemic effect of a meal (in particular triglycerides), while post-meal exercise has a beneficial effect on PPG.^[28,30-32] However, evidence points to the fact that the degree of improvement of postprandial triglycerides and glucose is more in South Asians than in European Caucasians.^[33] In a recent meta-analysis, post-meal exercise (such as 20 min walking), when undertaken as soon as possible after a meal, reduced PPG excursions more than premeal exercise (standardized mean difference = 0.55 (95% confidence interval [CI]: 0.34, 0.75) with longer intervals weakened the effect.^[30] In a study conducted in India, walking 1500–1600 steps for 15 min, starting 15 min after each meal, was compared with one-time daily exercise (45 min prebreakfast walking at a stretch covering 4500–4800 steps).^[31] In this study, HbA1c and post-lunch glucose were reduced by –0.7% and –46 mg/dl, respectively, for the post-meal exercise group compared with + 0.3% and + 20 mg/dl, respectively, for the prebreakfast exercise group.^[31]

Recommendation 2: Timing of exercise with regard to meal

- Exercising any time of the day is beneficial
- Exercise in the fasting state has a favorable impact on lipemia
- Post-meal exercise (0–30 min after meals) has a better effect on post-meal glycemic excursions than premeal exercise

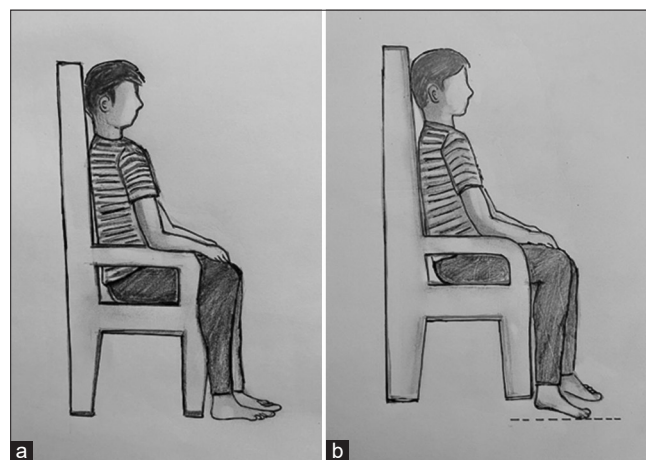


Figure 2: (a) Soleus push up exercise, While sitting, rest the feet on the floor with the knees bent at a right angle. (b) Then, lift your heel up and down keeping your toes on the ground. This exercises the soleus muscle, without involving the other big muscle groups

- Hence, dividing an exercise regime into two parts, one in the fasted state, and one in the post-meal state, could provide maximal benefit.

EXERCISE AND HYOGLYCEMIA PREVENTION FOR THOSE ON ORAL HYOGLYCEMIC AGENTS

During exercise, once muscle glycogen is depleted, the muscles rely on glucose derived from hepatic gluconeogenesis.^[33-36] Gluconeogenesis is stimulated by cortisol, catecholamines, and glucagon, and insulin, which is a counter hormone to glucagon, is reduced to allow this process to take place.^[37] Hence, if insulin levels are increased, either by exogenous insulin or insulin secretagogues, hepatic glucose production will be inhibited, and muscle uptake of glucose will be enhanced, leading to hypoglycemia.^[36]

Brief, intense aerobic exercise increases blood glucose levels due to catecholamine secretion.^[33,34] Resistance exercise usually does not have any acute effect on blood glucose.^[35]

Recommendation 3: Exercise consideration for those on OHA

- Patients on insulin secretagogues like sulfonylureas and glinides are associated with an increased risk of hypoglycemia during exercise necessitating special considerations, while those on agents such as metformin, thiazolidinediones, Dipeptidyl peptidase 4 (DPP-4) inhibitors, Glucagon-like peptide 1 (GLP-1) receptor agonists, alpha-glucosidase inhibitors and Sodium-Glucose Transport Protein 2 (SGLT-2) inhibitors do not need any dose adjustment for exercise
- A brief high-intensity sprint of 10 s before moderate-intensity exercise gives protection against hypoglycemia
- Exercise should be withheld if there is a history of severe hypoglycemia within the previous 24 h
- Glucose level <70 mg/dl: Take 15 g fast-acting carbohydrate (15 g glucose/sugar). Retest after 15 min. Once glucose >100 mg/dl – may do low to moderate intensity exercise. Follow with slow-acting carbohydrate (250 ml milk or 2 biscuits or 1 piece of fruit)
- Glucose level 71–100 mg/dl: Follow as above
- Glucose level 101–270 mg/dl: May proceed with exercise. Carry 15 g of slow-acting carbohydrate
- Glucose level more than 270 mg/dl: If feeling unwell, then do not exercise. Otherwise, proceed with low-intensity exercise, monitor glucose levels, and increase fluid consumption

EXERCISE IN THOSE ON INSULIN

Aerobic exercise increases muscle glucose uptake through insulin independent (~2 h) and insulin-dependent mechanisms (~48 h if exercise is prolonged).^[38] Short-duration activity (~20 min) with intermittent high intensity, as well

as low-intensity exercise lasting ≥60 min, increases insulin sensitivity for at least 24 h.^[39] The improvement in insulin sensitivity is exercise dose dependent, with improvement seen from expending just 400 kcal/week and increasing up to 2500 kcal/week.^[40]

Longer-duration, high-intensity physical activity increases the risk for postexercise hypoglycemia in those on insulin. This can be reduced by performing a brief maximal intensity sprint (for 10 s) before or after exercise, or by performing high-intensity bouts intermittently during exercise or by performing resistance exercise immediately before aerobic exercise, if not contraindicated.^[35]

Carbohydrate intake recommendation during exercise and insulin dose adjustment for T2DM on basal-bolus regime is extrapolated from advice for T1DM, as outlined in Tables 1 and 2.

The risk of exercise-induced nocturnal hypoglycemia can be reduced through 20% reductions of daily basal insulin dose with reduced prandial bolus insulin and low glycemic index carbohydrate intake following evening exercise for those on multiple daily insulin injections.^[35] The inclusion of a bedtime snack and overnight glucose monitoring may help minimize the risk of nocturnal hypoglycemia following exercise.^[41]

Table 1: Intervention in type 2 diabetes mellitus patients on basal-bolus insulin regime^[27]

| Blood glucose level before start of exercise (mg/dL) | Suggested carbohydrate intake |
|--|---|
| <90 | Take 15–30 g quick-acting carbohydrate Exercise <30 min or very high-intensity exercise (weight training, HIIT) may not need additional carbohydrate |
| 90–150 | Take carbohydrate 0.5–1 g/kg body mass/h of exercise |
| 150–250 | Delay carbohydrate intake till glucose levels are <150 mg/dL |
| 250–350 | Avoid exercise if moderate-to-large amounts of ketones are present |
| >350 | Avoid exercise if moderate-to-large amounts of ketones are present |

HIIT: High-intensity interval training

Table 2: Suggested reduction in bolus insulin for exercise performed within 2–3 h after a meal^[36]

| Exercise intensity | Percentage of bolus dose reduction | |
|---|------------------------------------|--------------------------|
| | Exercise duration 30 min | Exercise duration 60 min |
| Mild (walking) | 25 | 50 |
| Moderate (light cycling, brisk walking) | 50 | 75 |
| Intense (running, intense cycling) | 75 | * |

*Exercise intensity is too high to sustain for 60 min

Extrapolating this to patients on premix insulin one may consider reducing breakfast premix insulin by 20% for daytime exercise and a similar reduction of dinner premix insulin for evening exercise.

Very intense exercise (sprinting) and heavy weightlifting promote hyperglycemia which can be mitigated using a conservative (50% of usual) correction dose of insulin or by aerobic cooldown.^[35,42]

Injecting insulin into the thighs should be avoided in those engaged in activity thereafter involving the thigh muscles as it could accelerate insulin absorption and increase the risk of hypoglycemia.^[43,44]

Recommendations 4: Exercise in patients on insulin

- The main consideration is to prevent hypoglycemia during and after exercise
- Two strategies may be adapted to mitigate hypoglycemia in insulin-requiring T2DM – either reduce insulin dose or consume extra carbohydrate
- Information regarding carrying carbohydrate and appropriate advice regarding the dose and time of consuming carbohydrate must be disseminated among patients

SHOULD PATIENTS WITH T2DM EXERCISE DURING PREGNANCY?

The first step in the treatment of gestational diabetes mellitus involves lifestyle management, of which physical activity and exercise is an integral part.

Before prescribing exercise, a thorough clinical examination should be done to rule out any medical reason to avoid exercise.^[45,46]

The ideal regime should include an exercise duration of 30 min, at least 3–4 times per week, with aerobic exercise (walking is the safest) being the most recommended. A practical approach to gauge the intensity of exercise is to use the “talk test” (An exercise intensity during which a conversation can be carried on), which equates to 60%–70% of heart rate reserve (heart rate reserve = Maximal heart rate (220-age) minus resting heart rate). Exercising with heavy weights should be avoided. Exercising in water is safe.

Patients should discontinue exercise if there is bleeding per vagina, abdominal pain, painful contractions, amniotic fluid leakage, breathlessness before starting exercise, chest

pain, headache, muscle weakness affecting balance, or calf swelling.

Recommendation 5: Exercise during pregnancy

- Exercise during pregnancy has multiple benefits to the mother and fetus
- Regular 30-min aerobic exercise for at least 3–4 times per week is recommended during pregnancy with “talk test” as the parameter to judge intensity.

EXERCISE FOR THE OLDER ADULTS WITH T2DM

The changes in body composition with aging include the decline of muscle mass and increase in abdominal fat, with the changes being more marked amongst Indians.^[47-51] Reducing sedentary time (e.g., sitting), independent of physical activities, improves cardiovascular, metabolic, and functional health in older adults.^[39-41] The activities may be unstructured (ex., climbing stairs) or anything that they can actually perform to begin with.^[51]

However, assessment of the levels of frailty, age-related disability, and comorbidities and individualizing their exercise prescription is important with attention to their physical environment, support, and resources.

Attempts must be made to combine exercise regimes, including resistance training, which preserves muscle strength and physical functioning, flexibility exercises, which maintain joint range movement and balance exercise, which reduce the risk of falls.^[52,53] Balance training should be closely supervised initially with less challenging postures to begin with.^[53] Aerobic exercise of moderate-intensity (150 min) or vigorous-intensity aerobic activity (75 min) weekly is recommended.^[54]

A sample exercise regime, building up gradually, is detailed in Table 3 with the advice of taking breaks during activities, if necessary.^[53]

Recommendation 6: Exercise for the older adults

- Reduce sedentary time. Any amount of exercise is better than nothing
- 150 min of moderate-intensity or 75 min of vigorous-intensity aerobic activity weekly is recommended
- Resistance exercises preserve muscle strength and physical functioning
- Balance exercises prevent falls and are strongly recommended

Table 3: A sample exercise prescription for older adults with type 2 diabetes mellitus^[44]

| Weeks | Aerobic activity (walking briskly) | Flexibility training (calf and thigh muscles) | Resistance training (lift 5 lb dumbbells, front and side arm raises) | Balance exercises (standing on one leg, heel or toe walking sideways, tai chi) |
|---------|------------------------------------|---|--|--|
| 1 and 2 | 3 days a week for 20 min each day | 3 days a week 5 min each day | 2 days a week for 2 sets of 5 repetitions each day | 1 h per week |
| 3 and 4 | 3 days a week for 30 min each day | 3 days a week 5 min each day | 2 days a week for 2 sets of 10 repetitions each day | 2 h per week |

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SHOULD PATIENTS WITH T2DM AND ISCHAEMIC HEART DISEASE EXERCISE?

Even though cardiovascular disease (CVD) is the leading cause of death in India, majority of the Indian population, including those with CVD, remain physically inactive.^[55] In patients with IHD, the benefits of regular exercise greatly outweigh the risks.^[56] Exercise-based cardiac rehabilitation in patients with IHD (mainly postmyocardial infarction and revascularisation patients) reduced cardiovascular mortality by 26% and hospital admissions by 18%.^[57] Those with IHD without the features in Table 4 should be considered to be at low risk for an exercise-induced adverse event.^[56] Clinical evaluation based on the presence of inducible ischemia may guide the exercise regime as highlighted in. In general, yoga and balance exercises are safe in IHD.

In mild-to-moderate heart failure (HF), exercise training improves exercise capacity and quality of life.^[56] Ideally, a supervised exercise-based cardiac rehabilitation program should be initiated while non-supervised home-based sessions are gradually added.^[56]

Recommendation 7: Exercise for the patient with ischaemic heart disease and/or heart failure

- IHD: If no high-risk features are present, then all activities are allowed. Ideally, exercise in a supervised exercise program, at least initially. Yoga, balance exercises to be encouraged
- Exertional angina: Heart rate to be kept at least 10/min below the start of exercise-induced angina
- Post myocardial infarction: Exercise in a supervised exercise program, at a low intensity initially. Both aerobic/resistance exercises are allowed
- HF: Advice against exercise if there is hypotension, hypertension at rest or during exercise and worsening HF symptoms. Aim for low/moderate intensity exercise, avoiding exercises that cause excessive rise in heart rate.

EXERCISE IN PATIENTS WITH T2DM AND RETINOPATHY

Diabetic retinopathy is an important microvascular complication of diabetes mellitus. Exercise reduces all macrovascular and microvascular complications of diabetes, including retinopathy.^[58,59]

Table 4: High-risk features for exercise-induced adverse cardiac events in ischaemic heart disease^[46]

| |
|---|
| >70% stenosis in a major coronary artery or >50% stenosis in the left main stem and/or fractional flow reserve <0.8 |
| Left ventricular ejection fraction ≤50% and wall motion abnormalities |
| Inducible myocardial ischemia on treadmill testing |
| Nonsustained ventricular tachycardia, frequent ventricular premature beats |
| Recent acute coronary syndrome±percutaneous coronary intervention or surgical revascularization (<12 months) |

A meta-analysis of 22 studies showed that physical activity reduces the risk of retinopathy in patients with T2DM (risk ratio (RR) = 0.94, 95% CI: 0.90–0.98, $P = 0.005$), which was more pronounced on vision-threatening retinopathy (RR = 0.89, 95% CI: 0.80–0.98, $P = 0.02$).^[49] Sedentary behavior was found to increase the risk of retinopathy, while moderate-intensity physical activity reduced the risk of retinopathy significantly (RR = 0.76, 95% CI: 0.58–1.00, $P = 0.05$).^[60]

However, retrospective data revealed that 5%–10% of vitreous hemorrhage may be associated with vigorous exercise.^[61] Hence, exercise regimes should be tailored to the degree of retinopathy. Ophthalmological screening before prescribing an exercise regime is recommended.

Recommendation 8: Exercise for patients with retinopathy

- Regular screening for retinopathy is recommended, particularly before prescribing high-intensity exercise
- There is no risk from physical activity in mild retinopathy
- With moderate nonproliferative retinopathy, activities that dramatically elevate blood pressure (like powerlifting, overhead lifting) should be avoided
- No exercise should be undertaken during a vitreous hemorrhage
- With severe nonproliferative and unstable proliferative retinopathy, avoid vigorous activity, jumping, jarring, head-down activities, breath-holding exercises, and activities that dramatically elevate blood pressure (like powerlifting, overhead lifting).

EXERCISE IN PATIENTS WITH NEPHROPATHY

Even in end-stage renal disease (ESRD), physical inactivity can lead to deterioration of physical performance and increase the risk of CVD.^[62,63] A recent meta-analysis indicated that physical activity was associated with an increase in glomerular filtration rate, a decrease in urinary albumin creatinine ratio, acute kidney injury, and rate of renal failure.^[64] Even in ESRD, a recent study in India found that aerobic and resistance intradialytic exercises had a positive effect on maximal oxygen consumption, quality of life, and sleep quality.^[65] However, an area of concern is the increased risk of falls in elderly individuals.^[66]

Exercise schedule should be individualized and planned after considering cardiovascular and physical tolerance, age, ethnicity, and access to resources of the patient [Table 5].

Recommendation 9: Exercise for patients with nephropathy

- In the microalbuminuria stage, all activities can be performed
- In overt nephropathy, exercise should be started at low intensity and increased gradually
- In ESRD, supervised moderate physical activity during dialysis helps to improve physical functioning, depression, and health-related quality of life.

Table 5: Typical exercise prescription for patients with diabetes and arthritis^[66]

| Modality | Examples | Duration and frequency |
|--|---|---|
| Aerobic | Walking, cycling, swimming | 4–7 days/week 30 min daily |
| Resistance | Elastic therapy bands, lifting weights. Involve major muscle groups | 2–3 days/week in nonconsecutive days Increase from 1–3 sets of 8–10 repetitions each at a weight that is 50% of the maximum that can be lifted in 1 repetition |
| Flexibility | Moving joints to their full range of movements. (ex: Yoga) | 2 days/week for 10 min/day. Hold each stretch for 30 s |
| Balance exercise (proprioceptive training) | Yoga, Tai chi, walking sideways/backward, heel/toe walking, standing on one leg, tilt board balancing | 2 days/week for 15–30 min |

T2DM WITH NEUROPATHY – WHICH EXERCISE?

Aerobic exercise is the most studied form of exercise in diabetic peripheral neuropathy (DPN), demonstrating improved endothelial function through augmented flow-mediated dilatation, better endothelial function through enhanced nitric oxide production, and reversal of the hypoxic state associated with DPN.^[67] Aerobic exercise in DPN also improves electrophysiological measures by improving lower limb edema, enhancing blood supply, and promoting neural collateral sprouting.^[67,68]

Both yoga training and conventional balance exercises in DPN have revealed effectiveness in augmenting balance and strength of performance, with yoga performing marginally better.^[67]

Autonomic neuropathy (AN), often unrecognized, may lead to multiple problems, including precipitation of cardiovascular events in cases of cardiac AN.^[35]

Regardless of the type of exercise, daily feet examination should be advised to detect and treat blisters, sores, or ulcers.

Recommendation 9: Exercise in patients with neuropathy

- Peripheral neuropathy: Appropriate footwear desirable like silica gel midsole, polyester or blend socks (not pure cotton). Focus on non-weight bearing exercise (cycling, swimming, sitting exercise)
- Local foot deformity: Focus on non-weight-bearing exercises to reduce plantar pressures
- AN: Avoid exercise with rapid postural or directional changes
- Avoid exercise in a hot environment and focus on adequate hydration with appropriate caution to prevent postural hypotension. Prior specialist advice is warranted in those with cardiac AN

SHOULD PATIENTS WITH T2DM WITH FOOT ULCER EXERCISE AT ALL?

Diabetic foot ulcers (DFUs) are a devastating complication of diabetes with a reported prevalence of 4%–10% of the diabetic population, with 50% occurring on the plantar surface of the foot.^[69] Apart from offloading strategies like total contact cast, patients are advised to limit weight-bearing activities, which may result in patients abandoning exercise altogether.^[70] Recent systematic reviews did not find sufficient evidence to

conclusively support nonweight-bearing exercises to assist in the healing of DFU.^[71,72] However, inactivity remains a modifiable risk factor for developing both macrovascular and microvascular complications of diabetes.^[73] In established DFUs, nonweight-bearing isotonic exercises like simple stretching/flexion and extension of limbs improve peripheral circulation with favorable effects on joint mobility and muscle quality.^[74]

Hence, risk–benefit balance should be considered while advising exercise in patients with DFU.

Recommendation 10: Exercise in patients with foot ulcer

- Aerobic exercise: Focus on nonweight-bearing exercises (exercise in sitting posture, upper limb exercise) and avoid brisk walking in the presence of unhealed ulcers
- Resistance exercise: Avoid weight-bearing and isometric exercises of the lower limbs, especially in the presence of ischemic component
- Flexibility exercise: May do, as long as weight bearing is avoided on the affected limb (for example: Shoulder flexibility exercise)

PATIENTS WITH T2DM AND ARTHRITIS – SHOULD THEY EXERCISE TOO?

Arthropathy in the form of adhesive capsulitis, osteoarthritis, and rheumatoid arthritis are frequently associated with Type 2 DM.^[75] Physical activity is one of the most important interventions capable of positively affecting the impairments that link aging, arthropathy, and T2DM.^[76] The ideal exercise prescription should include a combination of the exercise modalities, as detailed in Table 5.^[76] However, a few key points need to be implemented along with guidance regarding stoppage or change of exercise.^[76]

- Shoulder mobilization exercises (to prevent frozen shoulder)
- Quadriceps and hamstring muscle strengthening exercises
- Increasing the grip size of tools, implements, and cookware to prevent trigger finger
- Avoidance of high-impact activities
- Appropriate footwear with maximum half-inch heels to prevent forefoot pressure.

Ideally, individuals with arthropathy should get an appropriate assessment by a specialist in Physical

Medicine and Rehabilitation for individualized exercise recommendation.

Advice regarding stopping or altering the exercise regime needs to be given in the following way:

- Mild-to-moderate joint pain: If pain perseveres 2 h after exercise, stop exercise for 1–2 days and reduce exercise amount and exercise different joints (example, if pain involves knees, then work on the upper body instead)
- Moderate-to-severe joint pain: Change to a different workout pattern that puts less pressure on joints – for example, swimming, underwater walking/exercise.

Recommendation 11: Exercise for patients with arthritis

- A combination of aerobic and resistance exercises is needed
- Flexibility exercise is important in preventing joint stiffness (ex. frozen shoulder)
- Balance exercise should be incorporated to prevent falls
- Low-impact exercises such as swimming, walking underwater should be encouraged

CONCLUSION

Physical activity and exercise must be an integral part of the prescription for every patient with diabetes, which will not only help glycaemic control but have a beneficial impact on overall health. The recommendations should be adapted to suit the specific needs of each patient. Apart from regular physical activity, advice should be given to reduce the total sedentary time and interrupt sitting time with bouts of activity.

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