Prediabetes and type 2 diabetes mellitus

Assessing risks for physical activity clearance and prescription

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The incidence of type 2 diabetes mellitus is high, primarily as a consequence of adverse health behaviour (eg, sedentarism, increased consumption of energy-dense foods), and unfortunately the incidence is expected to increase further in all age groups over the next few decades, possibly affecting 2.5 million Canadians by the year 2016.[1] Statistics Canada currently estimates that some 6% of male and 5% of female Canadians older than 12 years of age have been diagnosed with diabetes,[2] and this is likely a conservative estimate of disease prevalence, given the large number of undiagnosed cases that long remain undetected owing to a lack of overt symptoms. The prevention, diagnosis, and management of type 2 diabetes, and its associated metabolic disorders, are likely to make ever greater demands upon health care professionals, with an increase in the case load of metabolic dysregulation driven by an aging population, a diversifying ethnic milieu, and a growing prevalence of the condition in young people.

There is compelling evidence that prediabetes (characterized by impaired fasting glucose or impaired glucose tolerance), metabolic syndrome, and type 2 diabetes can all be both prevented and treated[3-5] by an increase in patients' habitual physical activity (PA). Nevertheless, preliminary "safety" screening issues and the subsequent supervision of exercise programs for patients with type 2 diabetes remain concerns in general practice.[6] Some health care providers and patients believe that exercise itself can pose certain risks for individuals with type 2 diabetes. This article provides an executive summary of findings from a systematic review of the risks of PA in prediabetes and diabetes[7]; it is one in a comprehensive series of reviews examining the risks of PA in patients with various chronic diseases. The evidence obtained from this review provides the foundation for new tools that will simplify the task of exercise clearance: the revised Physical Activity Readiness Questionnaire (PAR-Q+)[8] and the electronic Physical Activity Readiness Medical Examination (ePARmed-X+) procedure.[9] Here we will briefly discuss the available published data on the risks of PA in prediabetes and type 2 diabetes, as well as present decision trees that help family physicians provide appropriate prescription of PA and that offer guidance for appropriate ongoing monitoring of patients.

Diabetes is frequently associated with both microvascular and macrovascular disease; depending on their extent, such pathologies can challenge the function of many organs and body systems, particularly the heart. The risks of cardiovascular disease (CVD) and secondary organ damage (eg, kidney, nerve, retina) have long been thought to place those with diabetes at a greatly increased risk of PA-related adverse events. Evidence suggests that glucose control (as indicated by hemoglobin A_{1c} concentrations) is directly linked to the chances of experiencing a cardiovascular event, with the risk increasing progressively with each 1% increase of hemoglobin A_{1c} above normal values.[10] Moreover, if a cardiac event does occur, the subsequent prognosis of patients with diabetes is typically worse than that in patients who do not have metabolic dysregulation.[11] Large-scale retrospective and epidemiologic studies present conflicting results on the safety of PA in diabetes: acute exercise (>6 metabolic equivalent task units) has been linked temporally to the occurrence of myocardial infarction[12]; but on the other hand, diabetes apparently had no effect on the presentation of adverse events during cardiac rehabilitation in almost 700 000 participants.[13]

Discussion

Thorough systematic review of the published literature on exercise testing and training in patients with prediabetes and type 2 diabetes revealed no evidence of any PA-related deaths and a very low incidence of non–life-threatening adverse events. This seems to suggest that nonvigorous (mild to moderate) PA is relatively safe in these individuals, despite their increased baseline risk of microvascular and macrovascular conditions, including CVD, nephropathy, and retinopathy. However, probably because of the perceived risks of exercise in this population, most published randomized control research studies carefully screened out their "high-risk" participants and included only those patients with few comorbidities (and specifically excluded individuals with advanced CVD). Moreover, exercise was generally limited to either mild or moderate intensity, with close clinical supervision. These caveats must be considered when assessing the evidence on the risks of PA for this class of patients.

Given available evidence on the incidence of PA-related adverse events in patients with impaired metabolic control, we conclude that the acute adverse event risk increases during and immediately following each bout of PA, but that in the long term,

risk progressively decreases as the patient persists with regular PA, as in healthy individuals. Although, the *overall* risk from PA appears to be low, it is important to consider individual patient characteristics such as age, diabetes-related complications and comorbidities, current and past metabolic control, and current lifestyle (eg, activity levels, smoking status), which can modify the risk of an adverse cardiovascular event. Specific recommendations for PA in patients with either prediabetes or diabetes (**Tables 1** and **2**,[14,15] respectively) must take into account these potential modifications of risk and are now provided in a new evidence-informed decision tree. These decision trees assist with risk assessment when initiating or increasing PA in patients with prediabetes and diabetes, and take into account the varying levels of information about individual patients that might be available to the family physician (**Figures 1** and **2**). We also reference the UKPDS (United Kingdom Prospective Diabetes Study) risk engine, an online tool (**www.dtu.ox.ac.uk**) to assist health care providers in determining the risk of future CVD events[14] in type 2 diabetes. Previous guidelines (from the American College of Sports Medicine and American Heart Association[16]) have called for screening to include noninvasive exercise

Table 1. PA and exercise recommendations for prescreening in individuals with prediabetes

RECOMMENDATION	LEVEL*	GRADE†
Because of their elevated baseline risk of CVD, patients with prediabetes should be screened for traditional and atypical signs and symptoms of CVD before initiating a new program of exercise	I	A
If no signs or symptoms for CVD exist in those with prediabetes or metabolic syndrome, no additional screening is required before the initiation of a new PA program, as the adverse events associated with increased PA (of low to moderate intensity) in asymptomatic individuals are low; if typical or atypical symptoms exist, then these individuals should be sent for specialist screening for CAD before starting any exercise program	II	A
For previously sedentary middle-aged and older individuals with prediabetes or metabolic syndrome, high-intensity PA should be avoided, at least initially, as it might place them at elevated risk of adverse cardiac events (eg, acute MI, sudden death) based on their higher likelihood of having some level of baseline CVD	IV	C
Youth with prediabetes should be considered to be at low risk of adverse events caused by increased PA; for these individuals, no additional screening is needed before the initiation of a new PA program	III	B

CAD—coronary artery disease, CVD—cardiovascular disease, MI—myocardial infarction, PA—physical activity.
*Level I evidence includes randomized controlled trials; level II evidence includes randomized controlled trials with important limitations or observational trials with overwhelming evidence; level III evidence includes observational trials; and level IV evidence includes anecdotal evidence or expert opinion.
†Grade A recommendations are strong; grade B recommendations are intermediate; and grade C recommendations are weak.

Table 2. PA and exercise recommendations for prescreening in individuals with type 2 diabetes

RECOMMENDATION	LEVEL*	GRADE†
Middle-aged and older patients with type 2 diabetes should be considered to be at moderate to high risk of CVD and sudden cardiac death	I	A
Because of middle-aged and older patients' elevated risk of MI associated with vigorous PA, rigorous screening should be conducted before the onset of a new PA program more vigorous than brisk walking	III	A
All patients with type 2 diabetes who have signs or symptoms suggestive of CVD, or a > 10% risk of having a cardiovascular event according to the UKPDS risk engine,[14] should seek medical approval before initiating a new PA program that includes activities more vigorous than brisk walking	IV	C
The > 10% risk according to the UKPDS risk engine corresponds approximately to meeting any of the following criteria[15]: • age > 40 y with or without CVD risk factors • age > 30 y and type 1 or type 2 DM of >10-y duration, hypertension, cigarette smoking, dyslipidemia, retinopathy, nephropathy, or microalbuminuria, or • any age and vascular disease (coronary, cerebral, or peripheral), autonomic neuropathy, advanced nephropathy with renal failure	IV	C
No restrictions should be placed on otherwise asymptomatic patients with type 2 diabetes for light to moderate activities	IV	C
Individuals with excessive hyperglycemia (fasting blood glucose > 15 mmol/L) and elevated ketone levels in their urine (ketonuria) should refrain from initiating vigorous exercise until glycemic control is reestablished	IV	C

CVD—cardiovascular disease, DM—diabetes mellitus, MI—myocardial infarction, PA—physical activity, UKPDS—United Kingdom Prospective Diabetes Study.
*Level I evidence includes randomized controlled trials; level II evidence includes randomized controlled trials with important limitations or observational trials with overwhelming evidence; level III evidence includes observational trials; and level IV evidence includes anecdotal evidence or expert opinion.
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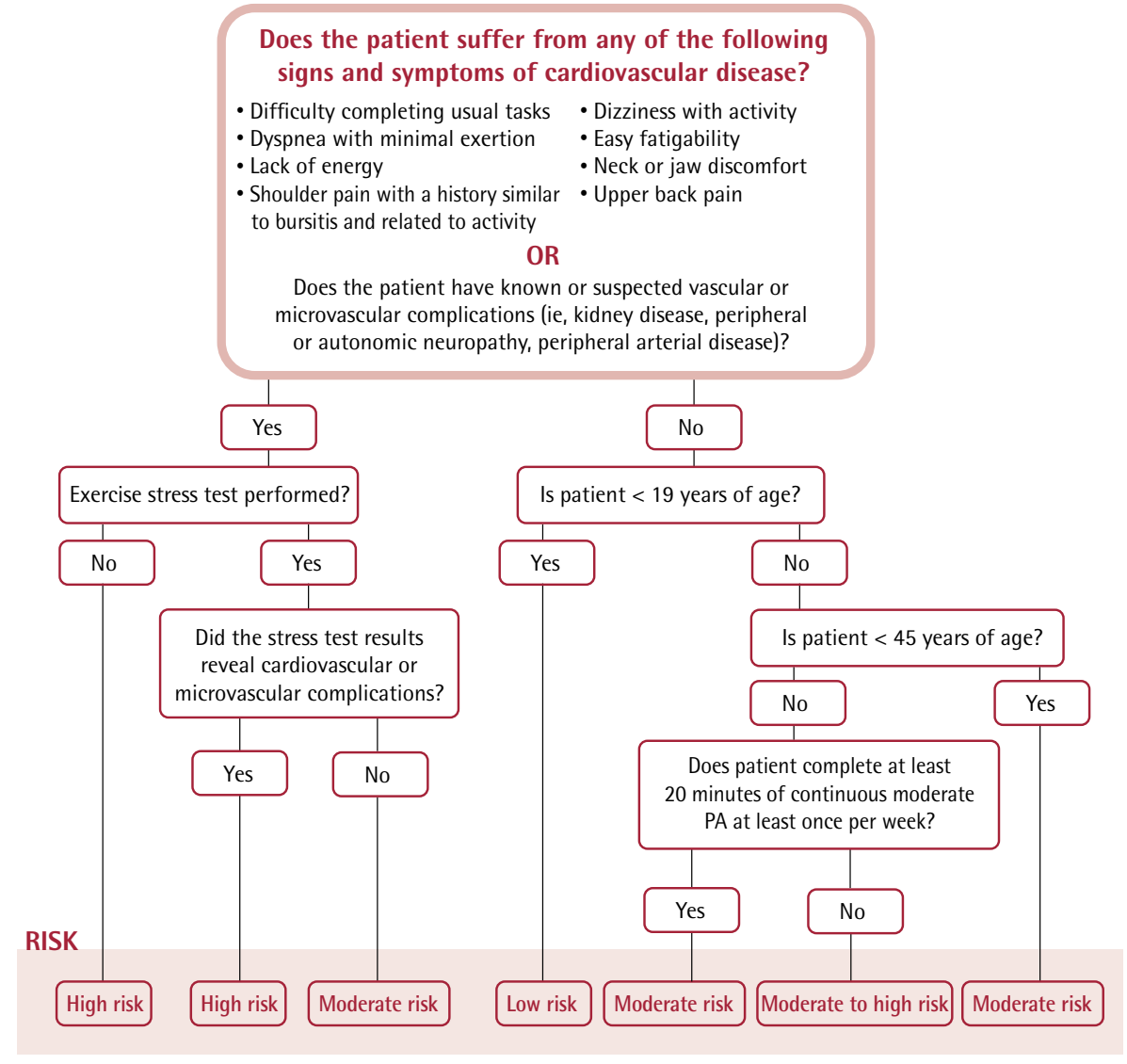
Figure 1. Clinical decision tree for assessing the risk of adverse events during PA in patients with prediabetes: *This decision tree can be used to categorize a patient as high, moderate, or low risk, informing both the requirements of PA prescription and the monitoring of exercise programs.*



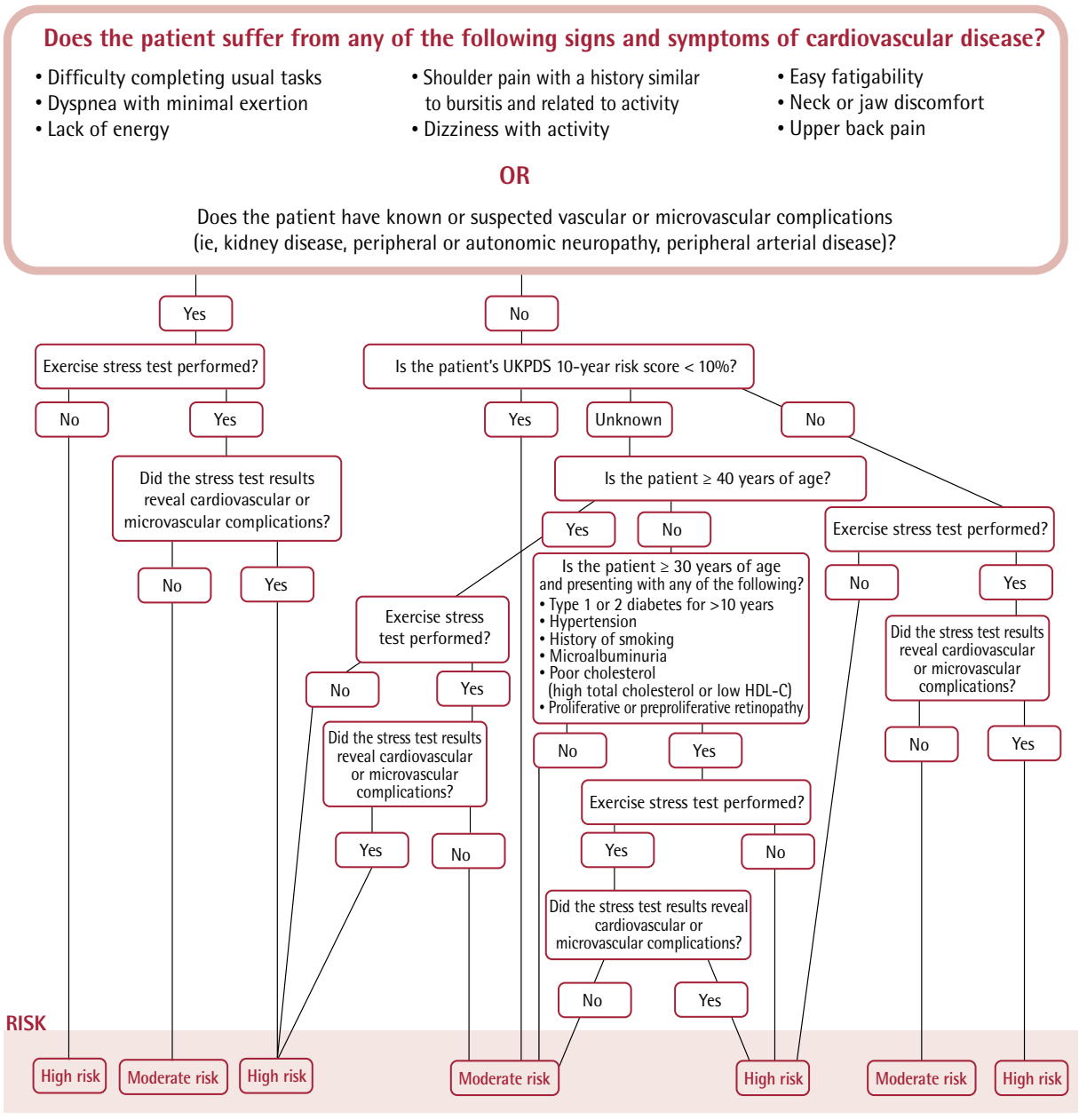
PA—physical activity.

stress testing in all asymptomatic individuals with 2 or more coronary risk factors (including hyperglycemia), and in all patients older than 40 years of age with only 1 CVD risk factor. We regard this recommendation as too conservative, and perhaps financially and logistically questionable; moreover, this sort of stress testing will likely present a considerable barrier to increased PA in those who would benefit the most from such a change of lifestyle (see the article by Riddell and Burr[7] for a full discussion). In our decision trees, we propose a modified screening approach, using an evidence-based approach and the UKPDS risk engine to predict the risk of a cardiovascular event in any given patient.

Conclusion

Those with prediabetes and type 2 diabetes are likely at slightly increased risk of PA-related adverse responses to exercise when compared with healthy individuals of the same age and fitness level. However, the risks of PA decline with habitual participation to levels that are comparable to the healthy population, and the benefits

Figure 2. Clinical decision tree for assessing the risk of adverse events during PA in patients with type 2 diabetes mellitus: *This decision tree can be used to categorize a patient as high, moderate, or low risk, informing both the requirements of PA prescription and the monitoring of exercise programs.*



HDL-C—high-density lipoprotein cholesterol, PA—physical activity, UKPDS—United Kingdom Prospective Diabetes Study.

of adopting a program of regular PA far outweigh the risks in the long term. Current evidence suggests that the acute risks of PA-related adverse events are low, and a careful prescreening of patients using the new decision tools will help ensure safe and effective exercise prescription, with appropriate monitoring and progression of activity levels.

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Competing interests
None declared

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