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PHYS THER. Published online February 7, 2013
Originally published online February 7, 2013

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Exercise Assessment and Prescription in Patients With Type 2 Diabetes in the Private and Home Care Setting: Clinical Recommendations From AXXON (Belgian Physical Therapy Association)

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In the management of type 2 diabetes mellitus (T2DM), exercise therapy is considered a cornerstone. Official position statements describe (1) the need for and effect of exercise therapy in patients with T2DM, (2) which training modalities to select, and (3) how to increase medical safety. However, the application of these guidelines in private and home care physical therapy settings might be difficult. Physical therapists working in private and home care settings often are limited in terms of equipment and space. It thus remains to be described for these physical therapists how to execute a valid preparticipation screening and how to increase the medical safety and clinical effectiveness of exercise training in patients with T2DM in presence of these limitations. Physical therapists, however, will manage these patients more often in the near future because of the increasing prevalence of this disease. In this clinical recommendation, a systematic, effective, and feasible approach for preparticipation screening and implementation of exercise intervention in patients with T2DM in presence of these limitations, is provided. Hereby, physical therapists in private and home care settings are better capable to prescribe clinically effective and medically safe exercise interventions for these patients.

Type 2 diabetes mellitus (T2DM) is a disease associated with many complications: the likelihood for the development of heart disease or stroke is elevated twofold to fourfold, and the prevalence of hypertension, retinopathy, and neuropathy in patients with T2DM is approximately 70%, 28%, and 60% to 70%, respectively. Moreover, T2DM is the most important cause of kidney failure and need for nontraumatic lower-limb amputation.1 Eventually, life expectancy is reduced by about 8.2 and 7.5 years in men and women, respectively, when T2DM is diagnosed at the age of 50 years.2 In addition to the hazardous effects of T2DM on health, economic and financial consequences of this disease have been described: health care–related costs are approximately twofold to threefold higher in patients with T2DM, as opposed to their healthy counterparts, not taking into account the economic costs related to absenteeism and lowered economic productivity.5

Recent statistical models indicate that the prevalence of T2DM will increase exponentially in the next few decades.4 The total number of patients with diabetes is projected to rise from 171 million in the year 2000 to 366 million in the year 2030.4 As a result, it is important to prevent T2DM and optimize medical treatment of T2DM to prevent the development of diabetes-associated complications and health care–related and economic costs.

In the care of people with T2DM, exercise intervention—besides pharmacologic treatment and caloric intake restriction—is considered a cornerstone. According to clinical guidelines, people with T2DM should permanently (lifelong) exercise 3 to 5 days a week, at a low to moderate intensity (40%–70% of maximum oxygen uptake [V̇O2max] or 50%–70% of maximal heart rate), achieving a minimal exercise duration of 150 minutes a week, and endurance exercises should be combined with resistance exercises (5–10 exercises per session, 3 series per exercise, 10–15 repetitions per series).5–7

Even though these guidelines are useful to physical therapists implementing exercise interventions in patients with T2DM, 2 major concerns still emerge. First, it remains to be described, in detail, what is the impact of a different selection of training modalities (exercise intensity, frequency, and duration; type of exercise; program duration) on the clinical effectiveness of exercise intervention in these patients.5–7 Second, and most importantly, it remains to be described how physical therapists, working in private and home care settings, need to imple-
ment these programs. More specifically, it remains to be described how to execute a preparticipation screening, how to screen for diabetes-associated complications, and how to increase the medical safety of exercise intervention, with the limited space and equipment that are available in private and home care physical therapy settings. It follows that guidelines for exercise therapy in T2DM need to be adapted to become applicable for physical therapists working in private and home care settings.

Considering the exponential increase in prevalence of T2DM, it is very likely that physical therapists working in private and home care settings will be confronted more frequently with patients with this disease in the near future. Accordingly, approximately 80% of all patients visiting physical therapists in outpatient settings have diabetes, prediabetes, or risk factors associated with diabetes. These patients are at elevated risk for microvascular and macrovascular complications, retinopathy, nephropathy, and neuropathy. It follows that awareness of medical safety and knowledge of the impact of exercise modalities in these patients needs to be increased in physical therapists working in private and home care settings.

The intention of this clinical recommendation is to describe a systematic, effective, and feasible approach for physical therapists, working in private and home care settings, who implement exercise interventions in patients with T2DM. With this approach, physical therapists are better capable to prescribe clinically effective and medical safe exercise interventions for these patients. The present recommendation consists of 4 main topics: (1) impact of exercise intervention in T2DM, (2) preparticipation screening, (3) increasing medical safety of exercise intervention, and (4) increasing the clinical benefits of exercise intervention.

Method of Selection of Preparticipation Tests and Training Modalities

This recommendation has been developed within the Flemish Working Group of AXXON (Belgian Physical Therapy Association). AXXON is the only officially recognized trade union for Belgian physical therapists and is a member of the World Confederation for Physical Therapy (WCPT). AXXON aims to increase the quality of physical therapy in Belgium (stimulate evidence-based practice), to govern professional practice, and to provide education at the national level. The aim of the present recommendation is to increase medical safety and clinical effectiveness of exercise intervention in T2DM when implemented by physical therapists working in private and home care settings. Moreover, with this document, AXXON aims to stimulate physical therapists to implement evidence-based preparticipation tests and exercise interventions in the management of T2DM.

To select proper preparticipation tests, it was first established which tests were necessary for physical therapists working in private and home care settings. In this selection, 2 criteria were handled: (1) tests should be feasible and (2) tests should be valid. Feasible tests were considered as those that could be executed in private and home care physical therapy settings, with minimum time investment and without need of expensive or large materials. Throughout this article, a difference between private and home care settings will be made in the selection of these tests. Valid tests were considered as those that actually measure what the physical therapist aims to measure. A preparticipation test was selected only when all members of the AXXON Working Group agreed. From the first group discussion, it was agreed that preparticipation tests should examine: medical safety, fall risk, physical activity, body composition, endurance exercise capacity, and muscle strength. In preparation for the subsequent meeting, the AXXON Working Group members searched for tests that could be implemented in private and home care physical therapy settings. Next, PubMed was consulted (up to October 2012) for studies examining the validity of these selected tests, against gold standard tests, in patients with T2DM. Data from these studies were discussed in the AXXON Working Group in the following meeting, and it was decided which tests were included in the present recommendation. Used key words, total number of hits, and number of relevant hits (studies examining patients with T2DM) are mentioned throughout the article for each preparticipation test.

Tests found to be invalid in patients with T2DM were not included. Tests that remained to be examined for validity in patients with T2DM but that did show sufficient validity in individuals who were healthy were included, but with the observation that these tests remained to be validated in patients with T2DM.

For the assessment of fall risk, the following tests were examined for validity in patients with T2DM: Timed “Up & Go” Test (TUG), Functional Reach Test (FRT), Berg Balance Scale (BBS), and Dynamic Gait Index (DGI). For the assessment of physical activity, the following instruments were examined for validity in patients with T2DM: questionnaires, pedometers, and accelerometers. For the assessment of body composition, the following methods were examined for validity in
patients with T2DM: bioelectrical impedance analysis (BIA), waist circumference, and body mass index (BMI). For the assessment of endurance exercise capacity, the following tests were examined for validity in patients with T2DM: step test, single-stage treadmill walking test, Six-Minute Walk Test (6MWT), and Astrand-Rhyming cycling test. For the assessment of muscle strength, the following tests were examined for validity in patients with T2DM: handgrip strength test, arm curl test, sit-against-wall test, and sit-to-stand test.

For the selection of training modalities and how to increase medical safety of exercise training, the current clinical guidelines were used as the starting point.5–7 However, based on recent studies,10 we further specified the selection of training modalities to optimize the clinical effectiveness of exercise intervention in T2DM. A summary of how to screen patients with T2DM, how to increase medical safety, and how to optimize the clinical benefits of exercise intervention is shown in Table 1.

Impact of Exercise Therapy in T2DM
Exercise interventions improve glycemic control significantly in patients with T2DM. Blood glycosylated hemoglobin (HbA1c) content has been reported to decrease by 0.7% to 0.8% as result of >12 weeks of combined resistance and endurance exercise training in patients with T2DM.11,12 Greater reductions in blood HbA1c content are to be expected in patients with T2DM with higher baseline blood HbA1c levels.12 Considering the significant relationship between blood HbA1c content and the risk of cardiovascular disease and premature death, such a decline in blood HbA1c content would lead to a reduction in risk of microvascular and macrovascular disease and premature death.13,14 Besides lowering blood HbA1c content in these patients, exercise interventions lead to improvements in exercise capacity, decreases in adipose tissue mass and increases in lean tissue mass, improvements in blood lipid profile and quality of life, and reductions in blood inflammatory markers and blood pressure.15–18 As a result, exercise interventions substantially reduce cardiovascular disease risk. Even an enhanced pancreatic β-cell function has been observed as result of exercise intervention in patients with T2DM, but only in those with moderate insulin-secretory capacity at entry of exercise intervention.19 Thus, exercise interventions are highly effective in improving glycemic control and cardiovascular disease risk profile and, therefore, should form a cornerstone in the care of patients with T2DM.5,7

Preparticipation Screening in T2DM
From the previous paragraph, it becomes evident that exercise intervention is important in the care of patients with T2DM. However, before initiating exercise interventions in these patients, a preparticipation screening that is feasible for physical therapists working in private and home care settings has to be executed. Such screening will contribute to detection of potential T2DM or exercise-related complications, assessment of fall risk, and quantification of physical activity, body composition, endurance exercise capacity, and muscle strength.

Medical Safety
A preparticipation screening is initiated by a clinical examination of the patient to detect potential complications related to T2DM and exercise. Patients with T2DM may experience the following complications: microvascular or macrovascular disease, retinopathy, nephropathy, peripheral or autonomic neuropathy, or orthopedic injury.7 A detailed description of these pathologies is presented in a previous review.9 To assess the presence of cardiovascular disease, retinopathy, nephropathy, or neuropathy, patients with T2DM should be examined by a cardiologist or sports physician, ophthalmologist, nephrologist, or neurologist, respectively. Obviously, most patients will be reluctant to visit all of these physicians at the start of exercise intervention, so physical therapists should adequately execute a preparticipation screening.

First, physical therapists should perform a thorough medical history check (recording reports of previous diseases, asking about current medical problems, and analyzing medication prescription). The following medications could be prescribed to patients with T2DM to lower blood glucose level: metformin and thiazolidinedione (to increase insulin sensitivity), alpha-glucosidase inhibitor (to lower glucose uptake in the gastrointestinal system), sulfonylurea, incretin, dipeptidyl peptidase 4 (DPP-4) inhibitor, meglitinide (to increase pancreatic insulin production), and exogenous insulin.20 In Table 2, the possible side effects of these blood glucose–lowering medications, especially during exercise training, are displayed. Furthermore, patients with T2DM often are prescribed a variety of medications for the control of blood pressure, lipid profile, and coagulation. These medications include diuretics, beta-blockers, angiotensin-converting enzyme (ACE) inhibitors, aspirin, and lipid-lowering medications. It is important to be aware that during exercise beta-blockers reduce heart rate, diuretics can lead to dehydration and electrolyte imbalances, and...
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**Table 1. Preparticipation Screening and Exercise Intervention in Type 2 Diabetes**

<table>
<thead>
<tr>
<th>Step</th>
<th>Measures</th>
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<tbody>
<tr>
<td><strong>Step 1: Preparticipation screening</strong></td>
<td></td>
</tr>
<tr>
<td>General medical risk</td>
<td>● PAR-Q (further examination on positive outcomes)</td>
</tr>
<tr>
<td>Specific medical risk</td>
<td>● Cardiovascular, neurologic (peripheral and autonomic), and orthopedic screening: refer to physician in case of severe or previously undetected anomalies&lt;br&gt;● Screening of nephropathy and retinopathy is not feasible: medical history/records should be examined&lt;br&gt;● Refer to physician in case of: untreated hypertension (blood pressure &gt;140/90 mm Hg), angina pectoris, previously undetected heart rhythm disturbances, untreated intermittent claudication, fasting hyperglycemia (blood glucose level &gt;16.8 mmol/L, &gt;300 mg/dL), frequent hypoglycemic episodes, untreated wounds in lower extremities, cachexia or sudden body weight loss, untreated autonomic or peripheral neuropathy, or untreated vision disturbances</td>
</tr>
<tr>
<td>Glycemic control</td>
<td>● Laboratory values (glucose, HbA1c)&lt;br&gt;● Medication treatment (biguanide, sulfonylurea, insulin, alfa-glucosidase inhibitor, bile acid sequestrant, meglitinide, DDP-4 inhibitor, thiazolidinedione, dopamine agonist, GLP-1 receptor agonist, blood pressure and cholesterol lowering medication, and anticoagulation)</td>
</tr>
<tr>
<td>Health parameters</td>
<td>● Fall risk (TUG, DGI)&lt;br&gt;● Physical activity level (pedometer/accelerometer)&lt;br&gt;● Body composition (bioelectrical impedance, waist circumference)&lt;br&gt;● Endurance exercise capacity (Astrand-Rhyming cycling test, 6MWT)&lt;br&gt;● Muscle strength (handgrip strength test)</td>
</tr>
<tr>
<td>Consider patient motivation to exercise</td>
<td></td>
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</tbody>
</table>

**Step 2: Increase medical safety during exercise training**

Take cardiovascular, neurologic, nephrologic, retinal, and orthopedic comorbidities into account before initiating exercise training

| Optimize glycemic control | ● Check blood glucose level before and after exercise training (should be 4.2–16.7 mmol/L, 75–300 mg/dL)<br>● Lower medication/insulin therapy in case of low blood glucose level (<4.2 mmol/L, <75 mg/dL) or symptoms of hypoglycemia before exercise training<br>● Elevate carbohydrate intake in case of low blood glucose level (<5.5 mmol/L, <100 mg/dL) or symptoms of hypoglycemia before exercise training<br>● Adjust training modalities (lower total exercise energy expenditure in case of low blood glucose level or symptoms of hypoglycemia; do not execute high-intensity exercise in case of blood glucose level >16.7 mmol/L, >300 mg/dL) |
| Optimize cardiovascular safety | ● Assess resting (60–100 bpm) and exercise (rate and rhythm) heart rate<br>● Assess blood pressure at start and end of exercise session (<140/90 mm Hg) |
| Optimize general medical safety | ● Retinopathy: avoid high-intensity exercise (>80% V\textsubscript{O}_{2}\text{max})<br>● Nephropathy: avoid hypertension (systolic blood pressure >180 mm Hg) during exercise<br>● Fever: postpone exercise training until body temperature is restored<br>● Peripheral neuropathy (with foot wound): avoid weight-bearing exercises<br>● Pregnancy: refer to gynecologist<br>● Autonomic neuropathy: regularly check heart rate and blood pressure<br>● Refer to physician when: development or worsening of hypertension, angina pectoris, heart rhythm disturbances, development or worsening of resting tachycardia, development or worsening of intermittent claudication, development or worsening of fast hypoglycemia, frequent hypoglycemic episodes, development or worsening of wounds in lower extremities, cachexia, autonomic neuropathy, or development or worsening of vision disturbances |

**Step 3: Optimize exercise training intervention**

| 3–5 days of exercise per week<br>Combine endurance training with strength training<br>Low to moderate endurance exercise intensities are effective (50%–75% V\textsubscript{O}_{2}\text{max})<br>Achieve a minimal exercise duration >150 minutes/week<br>Strength exercise modalities: 5–10 exercises/session, 3 series/exercise, 10–15 repetitions/series<br>Aim at permanent increase in physical activity level<br>In case of obesity: increase exercise volume or caloric expenditure (to 250 minutes/week)<br>In case of sarcopenia or low muscle strength: elevate strength training volume<br>Base exercise intensity on heart rate reserve<br>Evaluate blood HbA1c content (goal <6.5%) to assess impact of exercise intervention |

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*PAR-Q—Physical Activity Readiness Questionnaire, HbA1c—blood glycosylated hemoglobin, DPP-4—dipeptidyl peptidase 4, GLP-1—glucagon-like peptide 1, TUG—Timed “Up & Go” Test, DGI—Dynamic Gait Index, 6MWT—Six-Minute Walk Test, V\textsubscript{O}_{2}\text{max}—maximum oxygen uptake.*
statins can lead to myopathies (myalgia, myositis). 5

Next, the physical therapist should fill out, together with the patient, the Physical Activity Readiness Questionnaire (PAR-Q). 21 In the PAR-Q, the patient responds to 7 simple questions. In case of a positive answer, the physical therapist should address this point in more detail. When the physical therapist believes that the reported complaint needs further examination or treatment, the patient should be referred to the appropriate medical specialist. A large body of evidence indicates that the PAR-Q is a sensitive tool for the detection of significant anomalies that will increase the risk of medical complications during exercise. 21

After a thorough interview and PAR-Q scoring, physical therapists should perform a clinical examination of the cardiovascular, neurologic, and orthopedic systems. First, the cardiovascular system is examined. The therapist should measure resting blood pressure and heart rate. When assessing blood pressure, the following guidelines should be used: blood pressure should be measured with a manual sphygmomanometer (with proper cuff) and a stethoscope, the patient must be sitting down for at least 5 minutes on a chair, the measured arm should be at the level of the heart, blood pressure always should be measured at the same arm, the patient should not consume caffeine-containing drinks or smoke cigarettes for at least 30 minutes before assessment, no exercises should have been performed for at least 30 minutes before assessment, and blood pressure should be measured at least twice (with averaging of results). 22 In the case of hypertension (blood pressure >140/90 mm Hg), heart rhythm disturbances, tachycardia (heart rate >100 bpm), and bradycardia (heart rate <60 bpm) with clinical symptoms, such patients should receive further attention and clinical examination.

To assess abnormalities in coronary circulation and myocardial function, exercise testing with continuous electrocardiographic (ECG) monitoring often is done. However, in patients with T2DM, routine exercise testing with ergospirometry and ECG monitoring is not advised. 5 The decision when to perform ergospirometry testing with ECG monitoring depends on the intensity of exercise (this testing should be done when T2DM patients participate in exercise interventions that will elicit

<table>
<thead>
<tr>
<th>Action</th>
<th>Medication</th>
<th>Interaction With Exercise Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in insulin sensitivity</td>
<td>Biguanide (metformin)</td>
<td>No weight gain, no risk for hypoglycemia during exercise training. Gastrointestinal side effects possible</td>
</tr>
<tr>
<td>Thiazolidinedione (rosiglitazone, pioglitazone)</td>
<td>Restricted in use or prohibited because of increased risk for acute myocardial infarction. No risk for hypoglycemia during exercise training</td>
<td></td>
</tr>
<tr>
<td>Dopamine agonist (bromocriptine)</td>
<td>No risk for hypoglycemia during exercise training. Side effects such as gastrointestinal complaints, nausea, dizziness, and fatigue possible</td>
<td></td>
</tr>
<tr>
<td>Increase in blood insulin level</td>
<td>Injectable insulin (short acting: human insulin (aspart, lispro); long acting: neutral protamine (hagedorn, detemir, glargine))</td>
<td>Significant weight gain might be expected. Significant risk for hypoglycemia during exercise training</td>
</tr>
<tr>
<td>Sulfonylurea (glyburide, glipizide, gliclazide, glimepiride)</td>
<td>Modest weight gain might be expected. Significant risk for hypoglycemia during exercise training</td>
<td></td>
</tr>
<tr>
<td>Meglitinide (nateglinide, repaglinide)</td>
<td>Modest weight gain might be expected. Significant risk for hypoglycemia during exercise training</td>
<td></td>
</tr>
<tr>
<td>Injectable glucagon-like peptide 1 (GLP-1) receptor agonist (exetanide, liraglutide)</td>
<td>Significant weight loss because of appetite suppression. Risk for hypoglycemia rare. Side effects such as nausea and vomiting possible</td>
<td></td>
</tr>
<tr>
<td>Dipeptidyl peptidase 4 inhibitor (saxagliptin, linagliptin, vildagliptin, sitagliptin)</td>
<td>No weight change expected. Risk for hypoglycemia during exercise rare</td>
<td></td>
</tr>
<tr>
<td>Decrease in carbohydrate absorption</td>
<td>Alpha-glucosidase inhibitor (miglitol, voglibose, acarbose)</td>
<td>Frequent gastrointestinal complaints. No risk for hypoglycemia during exercise training</td>
</tr>
<tr>
<td>Bile acid sequestrant (colesevelam)</td>
<td>Frequent gastrointestinal complaints. No risk for hypoglycemia during exercise training</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Commonly Used Glucose-Lowering Medications in Type 2 Diabetes and Interactions With Exercise Training 21
exercise intensities above those achieved during brisk walking). Additionally, maximal ergospirometry testing with ECG monitoring should be done in patients less than 30 years or more than 40 years of age and with the presence of one of the following criteria: diabetes diagnosed more than 10 years previously, hypertension, cigarette smoking, dyslipidemia, retinopathy, or nephropathy. In the case of diagnosed or suspected coronary artery disease, peripheral arterial disease, cerebrovascular disease, autonomic neuropathy, or severe nephropathy (renal failure), such exercise testing also is indicated. An evaluation of peripheral vascular status should include assessment of pain, changes in extremity color, temperature, pulsations of peripheral arteries (dorsalis pedis, tibialis posterior), and appearance of nails. When a patient complains of having peripheral muscle pain that is provoked by walking and disappears during subsequent recovery, this complaint might indicate intermittent claudication.

Second, the neurologic system is examined. Peripheral neurologic status can be assessed by the combined use of the DN4 questionnaire and monofilament testing. The DN4 questionnaire is first filled out by the patient (first 7 questions), after which physical therapists administer simple tests to assess sensitivity at reported sites with sensitivity disorders (final 3 questions). When more than 3 out of 10 questions of the DN4 questionnaire are answered positively, this indicates neuropathic pain (80% sensitivity and 92% specificity). A monofilament (Semmes-Weinstein) test will further establish the degree of peripheral neuropathy (88% sensitivity and 57% specificity when compared with the Neuropathy Disability Score). During this assessment, a 10-g monofilament for cutaneous pressure assessment is used, and a needle is used for pain sensation assessment. To assess pressure perception, the monofilament is pressed against the skin until it buckles and held for 2 seconds. This test is performed twice on the plantar surface of each hallux and the 1st, 2nd, 3rd, and 5th metatarsal heads. The patient is asked to confirm whether a stimulus is felt. The number of sites at which the monofilament is felt is recorded out of 10 for each foot, after which a categorization will follow: normal pressure perception (being able to feel >8/10 sites) or abnormal pressure perception (being able to feel ≤8/10 sites).

Within the neurologic assessment, the clinical investigation of the feet is important. During this assessment, the feet and shoes should be inspected. Shoes that are worn out or too narrow are inappropriate for wear. When examining the feet, dermatologic risk factors (eg, abnormal color, dryness, cracking, sweating, infection [mainly fungal infection between toes], ulceration, blistering), musculoskeletal risk factors (eg, deformity, muscle wasting), neurologic risk factors (as mentioned above), and cardiovascular risk factors (eg, reduced peripheral pulsations) should be examined.

Third, the orthopedic system is examined for the following complications: diabetic hand syndrome, Dupuytren contracture, trigger finger, frozen shoulder, Charcot foot, diffuse idiopathic skeletal hyperostosis, osteoarthritis, and orthopedic misalignment.

Orthostatic hypotension is defined as a decrease in systolic blood pressure of greater than 30 mm Hg or a decrease in diastolic blood pressure of greater than 10 mm Hg when changing from a supine to standing position. A slowed heart rate recovery after exercise also is typically associated with autonomic neuropathy.

The presence of nephropathy is difficult to assess without blood parameters (urea nitrogen, creatinine, glomerular filtration rate). Patients with chronic kidney disease typically report polyuria, polydipsia, or peripheral edema. These symptoms, however, also could be present in patients with T2DM without nephropathy. Retinopathy cannot be diagnosed by physical therapists. However, a worsening in vision indicates a progressive deterioration of eye function as result of this diabetes-mediated retinopathy.
Based on such thorough clinical examination, physical therapists should be sufficiently aware of absolute or relative contraindications to exercise training, or anomalies that require changes in the exercise program. Patients with T2DM should be referred to a physician before initiating the exercise intervention in the following situations or conditions: untreated hypertension (blood pressure >140/90 mm Hg), angina pectoris, previously undetected heart rhythm disturbances, untreated intermittent claudication, fasting hyperglycemia (blood glucose level >16.8 mmol/L, >300 mg/dL), frequent hypoglycemic episodes, untreated wounds in the lower extremities, cachexia or sudden body weight loss, untreated autonomic or peripheral neuropathy, and untreated vision disturbances.

In conclusion, during the first part of the preparticipation screening, physical therapists screen patients for the general risk for complications and examine the cardiovascular, neurologic, and orthopedic systems and the feet.

**Fall Risk**

Patients with T2DM, especially those older than 65 years, are at an increased risk of falling or show an increased fall rate. This condition could lead to increased morbidity and mortality. It is important, therefore, to assess fall risk when initiating an exercise intervention in these patients (key words: fall risk, balance, assessment, diabetes; total number of hits=379; relevant hits=reference 31). Recently, the validity of the TUG, FRT, BBS, and DGI has been compared in patients with T2DM.31 When adjusting the cutoff scores, the TUG showed the greatest sensitivity (90%) and specificity (88%).31 In this test, the patient stands up from a supine position, walks 3 m, turns around, walks back to the chair, and sits down.52 This test should be completed within 10.6 seconds; a longer duration predicts greater risk for falling.

Another test with sufficient sensitivity (90%) and specificity (85%) to assess fall risk in patients with T2DM is the DGI.31 The scoring of each item of the DGI ranges from 0 to 3. A score of 0 indicates that the individual is unable to perform the walking skill, and a score of 3 indicates the individual can perform the skill normally. A patient with a total score of 22 or lower is prone to increased fall risk.31 The great disadvantage of the DGI is the time needed for execution (approximately 15 minutes).

Both the TUG and DGI can be executed in private and home care physical therapy settings. These tests are recommended for the assessment of fall risk in patients with T2DM, although with adjusted cutoffs.

**Physical Activity**

Typically, patients with T2DM are sedentary. It is important to assess physical activity to understand the severity of physical inactivity (key words: physical activity, pedometer, accelerometer, step count, validity, diabetes; total number of hits=83; relevant hits=references 33–37). Moreover, it is advised to regularly assess physical activity to understand the impact of exercise intervention on home-based physical activity.

For the assessment of physical activity, specific questionnaires for T2DM patients have been developed (modified International Physical Activity Questionnaire and Physical Activity Questionnaire for Diabetic Patients).33,34,36 However, these questionnaires are prone to severe error in estimation of physical activity ($r=.24-.62$ between self-reported physical activity and directly assessed physical activity).33,34,36 Therefore, it is proposed to measure physical activity directly with objective techniques, as stated in clinical guidelines.38

For physical therapists working in private and home care settings, accelerometers or pedometers could be used to assess physical activity in patients with T2DM.37 The patient needs to wear this monitor at the hip level for 3 to 5 consecutive days (except during sleeping), after which the physical therapist can determine the physical activity level.38 During such assessment, it is important that the patient is not able to observe the registered physical activity level on this monitor and that the patient does not suddenly change his or her physical activity during the assessment period.

An accelerometer is not sensitive to changes in inclination during walking or carrying an extra load during walking, does not monitor upper body activity, and is less applicable for assessing cycling activity.38 Moreover, an accelerometer is more expensive and requires more intense data management. From the data gathered using this monitor, energy expenditure related to physical activity and exercise duration and intensity can be calculated. However, physical therapists should remain cautious with the registered exercise intensity, as this parameter depends on what cutoff values are used to determine different levels of exercise intensity.38

A pedometer also is a simple apparatus that provides a valid estimation of physical activity, is less costly, and data are easier to manage, but can only be used to specifically assess walking activities.38 Also, pedometers and accelerometers may be limited by body size of patients and,
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could be categorized according to different physical activity levels: <5,000 steps/day = inactive, 5,000–7,499 steps/day = low active, 7,500–9,999 steps/day = somewhat active, 10,000–12,499 steps/day = active, and ≥12,500 steps/day = highly active. A step frequency of >100 steps/minute is considered moderate-intensity to high-intensity walking activity. In conclusion, for the assessment of physical activity in patients with T2DM, pedometers or accelerometers are advised.

Body Composition

Type 2 diabetes often is associated with excessive adipose tissue mass. It is important to obtain a proper determination of adipose tissue mass because visceral adipose tissue mass is an important contributor to the development and maintenance of T2DM and cardiovascular disease (key words: waist circumference, dxa, bmi, bioelectrical impedance analysis, diabetes, validity; total number of hits = 103; relevant hits = references 40–46).

To assess adipose tissue mass, medical imaging techniques such as x-ray computed tomography (CT) scan, dual x-ray absorptiometry (DEXA) scan, and magnetic resonance imaging (MRI) scan are the gold standard techniques. For obvious reasons (financial cost and technical complexity), these techniques are not available to physical therapists in private and home care settings. It follows that feasible, but valid, techniques for the estimation of adipose tissue mass are needed.

Adipose tissue mass can be estimated using BIA. This technique has been validated against DEXA scan (r = .89–.96) in patients with T2DM. In this regard, bipolar (feet) BIA scales can be used; tetrapolar BIA weight scales do not have a greater validity in adipose tissue mass assessment. However, it has been shown that changes in adipose tissue mass as result of exercise intervention is not always properly estimated by BIA in patients with T2DM, even though high correlations have been reported with DEXA scan (r = .86). When conducting BIA, it is important to adhere to the following guidelines: feet should be clean, the patient should abstain from exercise training during the preceding 24 hours, dehydration should be absent, and excessive fluid intake should be avoided in the preceding 24 hours.

As an addition to BIA, waist circumference should be assessed. By measuring waist circumference, a valid estimation of abdominal adipose tissue mass can be obtained in T2DM patients (r = 0.53–0.83 with MRI and DEXA scan). The most valid assessment location of the waist circumference is right above the iliac crest (r = .85–.92 with DEXA scan). However, this assessment technique is not always easy, especially in patients who are obese, because the iliac crest needs to be determined accurately. The waist circumference is measured with nonelastic tape with the patient in a standing position after full expiration. In men and women, a waist circumference of <102 cm and <94 cm, respectively, is considered normal.

It might be proposed to calculate BMI. Even though this parameter often is assessed for epidemiologic study or observation, at the individual level, this parameter does not always accurately reflect adipose tissue mass in patients with T2DM (correlation between visceral adipose tissue mass measured by medical imaging technique and BMI in patients with T2DM: r = .71 in women and r = .56 in men). Moreover, BMI provides a less valid estimation of adiposity in case of strength-trained athletes, older people, and people with fluid disturbances (eg, heart failure, peripheral edema, ascites) and is different between men and women and in different ethnic groups. These limitations should be taken into account when evaluating BMI.

In the home care setting, waist circumference can be assessed; in the private setting, both waist circumference and adipose tissue mass (by BIA) can be assessed. In conclusion, in the evaluation of body composition in patients with T2DM, the assessment of waist circumference and adipose tissue mass by BIA is recommended.

Physical Fitness

Endurance exercise capacity. The assessment of endurance exercise capacity is important. It provides feedback to physical therapists and patients about the clinical effectiveness of exercise intervention. Moreover, a higher endurance exercise capacity predicts greater survival in patients with T2DM. According to clinical guidelines, the gold standard technique to assess endurance exercise capacity is a cardiopulmonary exercise test with ergospirometry. During such testing, a direct assessment of VO2max can be done, and medical safety of exercise can be checked.

In private and home care physical therapy settings, however, 2 problems emerge with this assessment method: (1) a maximal exercise test is required (which is not allowed to be performed by physical therapists in some countries), and (2) this
method requires the availability of an ergospirometer (which is too expensive for many physical therapists) and high levels of technical skill.

For these reasons, for the preparticipation screening of patients with T2DM at low risk for cardiovascular complications, physical therapists in private and home care settings are in need of submaximal exercise tests (with sufficient validity) without ergospirometry. These submaximal exercise tests are designed to estimate \( V\dot{O}_2_{\text{max}} \) and use the heart rate in such estimations (key words: submaximal exercise, walking, cycling, Astrand, treadmill; total number of hits=557, relevant hits=reference 51).

The Astrand-Rhyming cycling test can be used to estimate \( V\dot{O}_2_{\text{max}} \). In this test, the patient cycles (at 50 rpm) against a self-selected constant workload (75–150 W), after which the corresponding steady-state heart rate (130–170 bpm) after at least 6 minutes of exercise can be observed. It is very important that a steady-state heart rate of at least 2 minutes is present. By using the Astrand-Rhyming nomogram, the predicted \( V\dot{O}_2_{\text{max}} \) can be calculated by connecting the selected workload with elicited heart rate. The validity of this test has been examined, with very different outcomes (from poor correlations to \( r=0.98 \) with assessed \( V\dot{O}_2_{\text{max}} \)). In patients with T2DM not taking beta-blockers, it has been found that the actually achieved \( V\dot{O}_2_{\text{max}} \) (as assessed by ergospirometry) is systematically different (27% lower) from the predicted \( V\dot{O}_2_{\text{max}} \) (as assessed with the Astrand-Rhyming cycling test). Changes in \( V\dot{O}_2_{\text{max}} \) during exercise intervention are different when using ergospirometry tests or submaximal tests with \( V\dot{O}_2_{\text{max}} \) prediction. Resting heart rate and heart rate behavior during exercise could be affected in patients with T2DM, especially in those with autonomic neuropathy. It should be mentioned that this finding is based on a single study examining 27 women with T2DM; studies including large cohorts of male patients with T2DM remain warranted. We conclude, therefore, that the Astrand-Rhyming cycling test could be used to estimate \( V\dot{O}_2_{\text{max}} \) and changes in \( V\dot{O}_2_{\text{max}} \) in patients with T2DM, knowing that estimation error could be present. In case of beta-blocker therapy, prediction of \( V\dot{O}_2_{\text{max}} \) is not feasible with the Astrand-Rhyming cycling test.

An alternative to the Astrand-Rhyming cycling test in case of beta-blocker intake is the 6MWT. This is a practical, simple submaximal test that requires a 30-m corridor. The patient is instructed to walk as fast as possible (verbal encouragement should be given) for a total duration of 6 minutes and is allowed to use walking aids. At the end of the test, total walking distance and Borg rating of perceived exertion are noted. Normal walking distance is predicted by the following formulas:

- For male patients, 6-minute walking distance (m) = \((7.57 \times \text{height [cm]}) - (5.02 \times \text{age}) - (1.76 \times \text{weight [kg]}) - 309\); for female patients, 6-minute walking distance (m) = \((2.11 \times \text{height [cm]}) - (2.29 \times \text{weight [kg]}) - (5.78 \times \text{age}) + 667\). By comparing the actually achieved total walking distance with this reference, level of physical fitness level can be calculated. However, the 6MWT does not estimate \( V\dot{O}_2_{\text{max}} \). Although walking capacity is significantly reduced in patients with T2DM, \( V\dot{O}_2_{\text{max}} \) is not feasible.

In conclusion, a maximal exercise test with ergospirometry and ECG analysis is indicated only in patients with T2DM with greater risk of complications or when high-intensity exercise is prescribed. To estimate \( V\dot{O}_2_{\text{max}} \) in patients with T2DM not taking beta-blockers, the Astrand-Rhyming cycling test could be used, even though some level of error is to be expected. To estimate functional capacity in patients with T2DM taking beta-blockers, the 6MWT is recommended.

**Muscle strength.** Muscle strength tests should be implemented to identify patients who are in need of strength training. In a study by Kim et al., a significant proportion of patients with T2DM (~16% prevalence, \( n=414 \), mean age=58 years) were sarcopenic compared with age-matched individuals who were healthy (~7% prevalence, \( n=446 \)). In addition, in a study by IJzerman et al., muscle strength was reduced by 30% to 50% in patients with T2DM compared with their healthy counterparts.

To examine muscle strength, dynamometry is considered the gold standard. However, considering the great financial cost of this device and the required technical skills, this test is not feasible for physical therapists working in private and home care settings. Feasible, low-cost, but valid strength tests are warranted for physical therapists in private and home care settings.
care settings (key words: handgrip strength, sit-to-stand test, chair stand test, arm curl test, half-squat test, diabetes; total number of hits=198, relevant hits=none).

The handgrip strength test shows moderate to high correlations with extremity muscle strength as observed during dynamometry testing (knee extensors, $r=.43-.99$), predicts prognosis, and is affected by exercise intervention, at least in individuals who are healthy.\(^9\)–\(^61\) However, the validity of this test remains to be examined in patients with T2DM. Therefore, we advise caution regarding the results obtained with this test. In this test, the patient sits on a chair with the elbow at 90 degrees of flexion and with a handgrip strength meter in the hand (the physical therapist supports the lower arm of the patient). Next, the patient squeezes the handgrip strength meter as hard as possible for 3 seconds. This test is performed 3 times, in both hands. Next, it can be observed whether the handgrip strength is normal.\(^61\) In case of acute or chronic injury of the arm or hand, the handgrip strength test is no longer valid for estimating whole-body muscle strength.

Another strength test that might be considered to assess muscle strength in patients with T2DM is the sit-to-stand test. Even though this test often was used in previous studies,\(^62\)–\(^64\) recent data indicate that the outcome of this test (sit-to-stand frequency) does not correlate with lower-extremity muscle strength, as assessed using a dynamometer, in individuals who are healthy (when controlled for age; $r=-.02$).\(^65\) The validity of this test is currently under intense debate.

In elderly people, the arm curl test often is assumed to have potential for assessing muscle strength in field settings. However, a recent study indicated that the outcome of this test shows no correlation ($r=.15$) with maximal muscle strength measured using a dynamometer.\(^66\) This test remains to be validated in patients with T2DM. Also, the wall sit test, or half-squat test, remains to be validated in individuals who are healthy.\(^59\)–\(^61\) It follows that the arm curl test and wall sit test are not proposed for muscle strength testing in patients with T2DM until further supporting evidence is available. In both home care and private physical therapy setting, the handgrip strength test is feasible. In conclusion, the handgrip strength test seems to be the only applicable field muscle strength test, even though this test remains to be validated in patients with T2DM.

### Increasing the Medical Safety of Exercise Intervention in Patients With T2DM

From a thorough preparticipation screening, physical therapists are aware of conditions that might increase the risk of complications during exercise. The exercise intervention should be adjusted according to these findings. However, even after such preparticipation screening, the medical safety of exercise training could be further increased by applying guidelines.\(^5,68,69\)

Hyperglycemia during exercise is not very common in stable patients with T2DM. When a pre-exercise glycemia of $>16.7$ mmol/L ($>300$ mg/dL) is detected, high-intensity exercise training should be postponed until confirmation that ketoadisosis is absent. Ketone concentrations can be examined using urine sample strips. When concentrations of ketones in urine samples that are too high are present, the patient should be referred to a physician. In the absence of ketoacidosis, patients with T2DM are allowed to perform low-intensity to moderate-intensity exercises. However, high-intensity exercise ($>80\%$ VO\(_{2\max}\)) is likely to further increase blood glucose level.\(^69\) It follows that such exercise intensities should be avoided in patients with T2DM who are hyperglycemic.

**Hypoglycemia** is a more common complication during exercise training in patients with T2DM. Several risk factors and situations should be taken into account when aiming to optimize blood glucose levels during exercise in patients with T2DM: type of medication (exogenous insulin therapy and sulfonylurea intake increase the risk for hypoglycemia), volume of exercise and amount of muscle mass involved in exercise training (greater exercise volume or total muscle recruitment increases the risk for hypoglycemia), level of physical fitness, pre-exercise blood glucose level (starting blood glucose level $<5.5$ mmol/L [$<100$ mg/dL] increases the risk for hypoglycemia), modalities of carbohydrate administration, nutritional status (training in a fasting condition or when skeletal muscles are glycogen depleted increases the risk for hypoglycemia), and patency of counter-regulatory hormones. With regard to insulin intake, the type of insulin, time elapsed since the last injection, form of administration, and injection site (proximity to exercising muscles) should be evaluated.\(^68,69\) Patients with pre-exercise glycemia of $<4.2$ mmol/L ($<75$ mg/dL) should consume monosaccharides (15 g) ahead of exercise. Those with pre-exercise glycemia of $<5.5$ mmol/L ($<100$ mg/dL) should be well aware of the risk of hypoglycemia during exercise. These patients should keep monosaccharides nearby and consume them when symptoms of hypoglycemia occur. Patients with T2DM receiving exogenous insulin therapy...
should adjust their insulin dose ahead of exercise training to avoid hypoglycemia (Tab. 3).69 When frequent hypoglycemic episodes do occur during exercise training, or in daily life, the exercise training protocol, glucose intake, and medication should be adjusted, in cooperation with a physician. It follows that the blood glucose content should be assessed regularly (immediately before and after exercise training, and a few hours after exercise training) to improve medical safety and to quantify the effect of exercise training. In addition, monosaccharides should always be available to patients with T2DM during exercise training.

Patients with diagnosed retinopathy should avoid high-intensity exercise training. Patients with diagnosed nephropathy should be careful to avoid developing hypertension (systolic blood pressure >180 mm Hg) during exercise training. In case of fever or acute bacterial or viral infection with clinical symptoms, exercise training should be postponed until full recovery from disease. Patients with peripheral neuropathy should wear proper shoes. In case of foot wounds, no weight-bearing activities should be performed. It is important that the feet are examined every week by the physical therapist to prevent development or worsening of food wounds. Patients with T2DM with autonomic neuropathy typically can develop blood pressure disturbances (hypertension, hypotension) during exercise, and heart rate during exercise is significantly altered. In these patients, heart rate and blood pressure, at rest and during exercise, should be checked regularly. Patients with T2DM who are pregnant should consult their gynecologist before proceeding with the exercise intervention. Exercise training modalities should be adapted according to findings from the orthopedic examination.

In the following situations and conditions during exercise training, patients with T2DM should be referred to a physician: development or worsening of hypertension, angina pectoris, heart rhythm disturbances, development or worsening of resting tachycardia, development or worsening of intermittent claudication, development or worsening of fasting hyperglycemia, frequent hypoglycemic episodes, development or worsening of wounds in the lower extremities, cachexia or sudden body weight loss, development or worsening of autonomic neuropathy, and development or worsening of vision disturbances.

In conclusion, medical safety of exercise training in patients with T2DM can be improved when regularly assessing blood glucose level, avoiding risk factors and situations for hypoglycemia, taking into account the presence of retinopathy or nephropathy, and referring back to a physician in case of certain alarming signs.

### Increasing the Clinical Benefits of Exercise Therapy in T2DM

Physical activity advice alone is far less effective when aiming to improve glycemic control in patients with T2DM, as opposed to supervised exercise training.12 It follows that in the treatment of T2DM, supervised exercise interventions should be set up. Physical therapists are well capable of further optimizing the clinical effectiveness of exercise intervention in patients with T2DM by adapting training modalities.10

In this respect, studies indicate that blood HbA1c content decreases or insulin sensitivity increases with significantly greater magnitude when increasing exercise frequency, adding resistance exercises to endurance exercises, or prolonging exercise intervention.10,70 Meta-analysis indicates greater reductions in blood HbA1c content when: increasing exercise frequency, prolonging par-

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**Table 3. Adjustments of Exogenous Insulin Therapy Dose Ahead of Exercise Training**

<table>
<thead>
<tr>
<th>Duration and Type of Exercise</th>
<th>Glycemia Pre-exercise</th>
<th>Insulin Adjustment Pre-exercise</th>
<th>Extra Glucose Intake During Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30 min low-intensity exercise</td>
<td>&lt;5 mmol/L, &lt;90 mg/dL</td>
<td>Half dose</td>
<td>10–15 g</td>
</tr>
<tr>
<td></td>
<td>&gt;5 mmol/L, &gt;90 mg/dL</td>
<td>Normal dose</td>
<td>None</td>
</tr>
<tr>
<td>30–60 min moderate-intensity exercise</td>
<td>&lt;5 mmol/L, &lt;90 mg/dL</td>
<td>Skip</td>
<td>30–45 g</td>
</tr>
<tr>
<td></td>
<td>5–10 mmol/L, 90–180 mg/dL</td>
<td>Half dose</td>
<td>15 g</td>
</tr>
<tr>
<td></td>
<td>&gt;10 mmol/L, &gt;180 mg/dL</td>
<td>Normal dose</td>
<td>None</td>
</tr>
<tr>
<td>&gt;60 min moderate-intensity exercise</td>
<td>&lt;5 mmol/L, &lt;90 mg/dL</td>
<td>Skip</td>
<td>45 g/h</td>
</tr>
<tr>
<td></td>
<td>5–10 mmol/L, 90–180 mg/dL</td>
<td>Half dose</td>
<td>30–45 g/h</td>
</tr>
<tr>
<td></td>
<td>&gt;10 mmol/L, &gt;180 mg/dL</td>
<td>Half dose</td>
<td>15 g/h</td>
</tr>
</tbody>
</table>
Participation to exercise intervention, and elevating exercise volume >150 minutes/week.12

Because patients with T2DM should achieve a permanent increase in physical activity, monitoring exercise motivation and barriers to exercise training is important. Physical therapists should regularly assess the motivation of the patient to exercise and ask for any practical or medical reasons that might complicate participation in an exercise intervention. Physical therapists, when possible, should intervene when barriers to exercise training emerge.

Continuous high-intensity endurance exercise interventions are equally effective, as opposed to continuous low-intensity endurance exercise interventions, to improve glycemic control in patients with T2DM (when matched for caloric expenditure).10,71 It remains to be shown whether high-intensity interval exercise training would translate into greater improvements in glycemic control in patients with T2DM.10,72 It should be mentioned that exercise training at higher intensities contributes to orthopedic injuries and lower exercise adherence, at least in individuals who are healthy.73 Therefore, physical therapists should be cautious when implementing high-intensity exercise interventions in patients with T2DM.

The addition of strength exercises on top of endurance exercises contributes to a greater improvement in glycemic control in patients with T2DM.19 Recently, the impact of different strength training modalities (intensity and volume), when combined with endurance exercise training, was examined. The first data indicate that high-intensity versus low-intensity strength training contributes to greater improvements in muscle strength, but does not affect changes in muscle mass and glycemic control in patients with T2DM.74

Based on the recommendations from clinical guidelines5-7 and data from individual relevant studies,10,70-74 the following recommendation for the selection of training modalities emerges: exercise training should start at a frequency of 3 days/week and build up to 5 days/week within a few months, at a low to moderate exercise intensity (40%-70% V02max), achieving a minimal exercise duration >150 minutes/week, in combination with resistance exercises (5-10 exercises/week, 3 series/session, 10-15 repetitions/session), and eventually leading to a permanently increased physical activity level. The required duration of an individual exercise session, however, remains unclear.10,75

Because most patients with T2DM are overweight or obese, training modalities should be adapted to maximize adipose tissue mass loss. Increasing exercise session volume (or greater total caloric expenditure) and prolonging the exercise intervention are effective modifications.5,10,76 In addition, in these patients, a caloric intake restriction intervention should be implemented.5,10 A greater visceral adipose tissue mass loss is instrumental to augment improvements in glycemic control in patients with T2DM.77 In case of sarcopenia, the volume of strength training should be sufficient or elevated.

A great challenge in exercise interventions for patients with T2DM is how to properly determine endurance exercise intensity. Considering the potential prevalence of autonomic neuropathy and obesity and intake of beta-blockers, using heart rate for determining exercise intensity might be complicated in patients with T2DM.53-78 It is advised, therefore, to take the resting heart rate into account and to calculate the heart rate reserve for more accurate endurance training intensity determination in patients with T2DM.79 In this method, the resting heart rate is assessed after the patient has been sitting for at least 5 minutes. Next, the target heart rate (HR) can be calculated with following formula: (maximum HR−resting HR) × % intensity) + resting HR. This method shows a greater validity for the determination of endurance exercise intensity in patients with T2DM, as opposed to ratings of perceived exertion.79,80

Blood HbA1c content should be assessed to determine the clinical effectiveness of exercise intervention in patients with T2DM. It is common practice to assess fasting blood glucose content in the follow-up of these patients. However, blood glucose level is affected by physical activity and food pattern during the preceding 24 hours, hydration status, and even acute psychological stress. It follows that changes in blood glucose level are not necessarily related to the effects of exercise intervention. Blood glycosylated hemoglobin, on the other hand, is not affected by these acute factors.

Conclusions
Exercise interventions are highly effective in improving glycemic control in patients with T2DM. In this regard, clinical guidelines have been published. However, these guidelines are not always applicable to physical therapists working in private and home care settings. In the present recommendation, a feasible, valid, and effective approach is formulated for physical therapists working in private and home care settings for the implementation of exercise intervention in patients with T2DM. By following these recommendations, the clinical effectiveness and
medial safety of exercise training will be improved.

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The authors received financial support from AXXON in the preparation of the manuscript.

Published Ahead of Print: February 7, 2013
Accepted: February 4, 2013
Submitted: October 2, 2012

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ProfessionWatch: Exercise Assessment and Prescription for Type 2 Diabetes


Exercise Assessment and Prescription in Patients With Type 2 Diabetes in the Private and Home Care Setting: Clinical Recommendations From AXXON (Belgian Physical Therapy Association)
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PHYS THER. Published online February 7, 2013
Originally published online February 7, 2013

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