Exercise prescription for patients with type 2 diabetes—a synthesis of international recommendations: narrative review

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ABSTRACT
Background Physical activity is a cornerstone of type 2 diabetes treatment and control.
Aim We analysed and synthesised the guidelines and recommendations issued by scientific organisations, regarding exercise prescription for patients with type 2 diabetes.
Method A systematic bibliographic search in Pubmed, Web of Science and Scopus databases was conducted. Clinical guidelines from major international scientific organisations in the field of diabetology, endocrinology, cardiology, public health and sports medicine were also considered. 11 publications were selected.
Results Published guidelines recommend a weekly accumulation of a minimum of 150 min of aerobic exercise at moderate-to-vigorous intensity spread over a minimum of 3 days per week. Resistance exercise for muscle strengthening is also recommended at least 2 days a week. Flexibility exercises may complement other types of exercise. Combining aerobic and resistance exercise within the same exercise session is recommended by most guidelines.
Conclusions Exercise prescription for individuals with type 2 diabetes should include specific information on the type, mode, duration, intensity and weekly frequency. The exercise strategies must be adapted for each individual, based on comorbidities, contraindications and realistic personal goals.

INTRODUCTION
Diabetes affects approximately 382 million people worldwide, accounting for 8.3% of the world’s population, and continues to increase in all countries—the number of people with diabetes is predicted to increase by 55% by 2035. Type 2 diabetes accounts for approximately 85–95% of all diabetes cases in the world. There are numerous guidelines for exercise advice in type 2 diabetes.

Guidelines recommend physical activity as a non-pharmacological therapeutic strategy fundamental to treatment and control of type 2 diabetes and related cardiovascular risk. It improves glycaemic control, insulin sensitivity, body composition, blood pressure and lipid profile, and mitigates other cardiovascular risk factors. However, the vast majority of patients with type 2 diabetes do not engage in regular exercise. The low prevalence of exercise practice in this population may be explained by the insufficient awareness about the potential benefits of exercise and the lack of specific knowledge about current recommendations. However, it may also be explained by behavioural barriers—a gap between knowledge and action. Although likely critically important, the latter is outside the scope of this paper.

We aimed to analyse and summarise the guidelines and recommendations issued by scientific organisations regarding exercise prescription for patients with type 2 diabetes.

METHODS
Bibliographic research was conducted in Pubmed, Web of Science and Scopus online databases, in December 2014, using the terms physical activity, exercise, type 2 diabetes, prescription, guidelines, recommendations, position and statement (search in title for: ‘physical activity’ OR exercise) AND ‘type 2 diabetes’ AND (prescription OR guidelines OR recommendations OR position OR statement)), with no limitation on publication date or language. Only publications issued by scientific organisations regarding the treatment of type 2 diabetes were selected.

Clinical guidelines from major international scientific organisations in the field of diabetology, endocrinology, cardiology, public health and sports medicine, regarding physical activity and exercise in the treatment of type 2 diabetes, were also analysed. The most updated publication was selected within each organisation.

RESULTS
Search in Pubmed, Web of Science and Scopus online databases resulted in locating 43 publications. Only six were subscribed by scientific societies. However, two of these documents were already out of date within the same organisation. A total of four papers were selected. From the direct analysis of major international scientific organisations clinical guidelines, seven publications were selected.

Table 1 summarises the 11 selected publications from International Diabetes Federation,2 European Association for the Study of Diabetes,3 American Diabetes Association,14 16 17 Francophone Diabetes Society, European Society of Cardiology,5 American Heart Association,18 American College of Sports Medicine,12 Exercise and Sports Science Australia,15 Belgian Physical Therapy Association,12 Canadian Diabetes Association19 and Swedish National Institute of Health.18
The importance of exercise as a cornerstone of diabetes treatment, particularly of type 2 diabetes, is recognised by major international scientific organisations in this field, such as the International Diabetes Federation, the European Association for the Study of Diabetes, or the American Diabetes Association.

Six of the selected documents are specific-exercise guidelines for the treatment of diabetes, four documents are general guidelines for the control of diabetes with specific recommendations for exercise prescription and one document is a publication with guidelines for exercise in the treatment of disease, with specific recommendations on diabetes.

Aerobic exercise recommendations

Published guidelines recommend the accumulation of a weekly minimum of 150 min of aerobic exercise with moderate intensity, an activity that can be conducted while maintaining an uninterrupted conversation (4–6 points in a rate of perceived exertion scale of 0–10) points in a rate of perceived exertion scale of 0–10 points, 12–13 points in a rate of perceived exertion scale of 6–20 points, or 40–59% of heart rate reserve, or 64–76% of the maximum heart rate) spread over a minimum of 3 days per week with no more than two consecutive days without exercise.

Alternatively, if there are no cardiovascular or musculoskeletal contraindications, patients are recommended to accumulate a weekly minimum of 90 min of vigorous-intensity aerobic

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**Table 1** Guidelines for exercise prescription in patients with type 2 diabetes, issued by several scientific organisations

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Type</th>
<th>Mode Description</th>
<th>Duration</th>
<th>Intensity</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACSM and ADA</td>
<td>Aerobic</td>
<td>Any form that uses large muscle groups (e.g., brisk walking)</td>
<td>Minimum of 150 min/week</td>
<td>Moderate</td>
<td>At least 3 days/week without more than 2 consecutive days</td>
</tr>
<tr>
<td></td>
<td>Resistance</td>
<td>Resistance machines and free weights involving major muscle groups</td>
<td>1–4 sets, 8–15 repetitions, 5–10 exercises on each session</td>
<td>Vigorous</td>
<td>At least twice weekly on non-consecutive days</td>
</tr>
<tr>
<td>FDS</td>
<td>Flexibility</td>
<td>Included as part of a physical activity programme; it should not substitute other types of exercise</td>
<td>Minimum of 150 min/week</td>
<td>At least moderate Vigorous</td>
<td>At least 3 days/week without more than two consecutive days</td>
</tr>
<tr>
<td>FDS</td>
<td>Aerobic</td>
<td>Exercises involving major muscle groups</td>
<td>3 sets, 8–10 repetitions, 5–10 exercises on each session</td>
<td>Vigorous</td>
<td>At least twice weekly on non-consecutive days</td>
</tr>
<tr>
<td>BPTA</td>
<td>Aerobic</td>
<td>For example, brisk walking</td>
<td>Minimum of 150 min/week OR</td>
<td>Moderate</td>
<td>No more than two consecutive days without exercising</td>
</tr>
<tr>
<td></td>
<td>Resistance</td>
<td>Large muscle activities (e.g., walking, running, cycling and swimming)</td>
<td>Minimum of 90 min/week OR</td>
<td>Vigorous</td>
<td>Two or more sessions per week</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multi joint exercises involving large muscle groups</td>
<td>2–4 sets, 80 min/week, 8–10 exercises on each session</td>
<td>Vigorous</td>
<td></td>
</tr>
<tr>
<td>CDA</td>
<td>Aerobic</td>
<td>For example, walking, brisk walking and continuous swimming</td>
<td>Minimum of 150 min/week OR</td>
<td>Moderate</td>
<td>At least 3 days/week without more than two consecutive days</td>
</tr>
<tr>
<td></td>
<td>Resistance</td>
<td>Resistance machines or free weights</td>
<td>3 sets, 8 repetitions, 5–10 exercises on each session</td>
<td>Vigorous</td>
<td>At least twice weekly</td>
</tr>
<tr>
<td>AHA</td>
<td>Aerobic</td>
<td>Large-muscle activities</td>
<td>Minimum of 150 min/week OR</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resistance</td>
<td>Multi joint exercises; large-muscle groups</td>
<td>2–4 sets, 8–10 repetitions, 8–10 exercises on each session</td>
<td>Vigorous</td>
<td>3–7 days/week</td>
</tr>
<tr>
<td>ADA</td>
<td>Aerobic</td>
<td>For example, walking, brisk walking</td>
<td>Minimum of 150 min/week OR</td>
<td>Moderate</td>
<td>At least twice weekly</td>
</tr>
<tr>
<td></td>
<td>Resistance</td>
<td>Free weights or weight machines involving large muscle groups</td>
<td>5 sets, 5 or more different exercises on each session</td>
<td>Vigorous</td>
<td>At least twice weekly</td>
</tr>
<tr>
<td>SNIPH</td>
<td>Aerobic</td>
<td>For example, brisk walking, cycling, for example, tennis, swimming</td>
<td>Minimum of 30 min, 20–60 min, 8–12 repetitions of each exercise</td>
<td>Moderate</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td>Resistance</td>
<td>Bodyweight, elastic bands, free weights or weight machines</td>
<td>8–10 repetitions, 8–10 exercises on each session</td>
<td>Vigorous</td>
<td>2–3 days/week</td>
</tr>
<tr>
<td>IDF</td>
<td>Flexibility</td>
<td>5–10 min at the end of aerobic and resistance exercise sessions</td>
<td>Minimum of 150 min/week OR</td>
<td>Moderate</td>
<td>3–5 days/week</td>
</tr>
<tr>
<td>ADA and EASD</td>
<td>Aerobic</td>
<td>For example, walking, brisk walking</td>
<td>Minimum of 150 min/week OR</td>
<td>Moderate</td>
<td>3 days/week</td>
</tr>
<tr>
<td></td>
<td>Resistance</td>
<td>Resistance machines or free weights</td>
<td>3 sets, 5–10 repetitions, 5–10 exercises on each session</td>
<td>Vigorous</td>
<td></td>
</tr>
<tr>
<td>ESC and EASD</td>
<td>Aerobic</td>
<td>For example, brisk walking, cycling</td>
<td>Minimum of 150 min/week OR</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resistance</td>
<td>Flexibility</td>
<td></td>
<td>Vigorous</td>
<td></td>
</tr>
</tbody>
</table>

ACSM, American College of Sports Medicine; ADA, American Diabetes Association; AHA, American Heart Association; BPTA, Belgian Physical Therapy Association; CDA, Canadian Diabetes Association; EASD, European Association for the Study of Diabetes; ESC, European Society of Cardiology; ESSA, Exercise and Sports Science Australia; FDS, Francophone Diabetes Society; IDF, International Diabetes Federation; SNIPH, Swedish National Institute of Public Health.
exercise, an activity in which a conversation generally cannot be maintained uninterrupted (7–8 points in a rate of perceived exertion scale of 0–10 points, 14–17 points in a rate of perceived exertion scale of 6–20 points, 60–89% of heart rate reserve, or 77–95% of maximum heart rate). Aerobic exercise can be practiced throughout the day in bouts of at least 10-min duration, and combinations of moderate and vigorous-exercise can be performed to accomplish total recommended aerobic exercise volume. For most patients with type 2 diabetes, brisk walking is a moderate-intensity aerobic exercise and jogging is a vigorous-intensity aerobic exercise. More benefits can be obtained by engaging in aerobic exercise volumes higher than the recommended amounts, which can be very important in cases of obesity.

Resistance exercise recommendations
Resistance exercise for muscle strengthening is also recommended in addition to aerobic exercise, despite the exercise dose not being unanimous. The most consensual recommendation seems to be the minimum weekly frequency of exercise—at least twice a week, on non-consecutive days. One to four sets of 5–10 multijoint exercises involving the major muscle groups are recommended per exercise session.

A slow progression of the number of sets and the load used is advisable. Initially, only one set of each exercise should be performed, with a load that allows the completion of 10–15 repetitions (50–69% of one repetition maximum—moderate intensity). After a few months of training, a load that does not allow the completion of more than 8–10 repetitions and that results in local muscle fatigue should be selected (70–84% of one repetition maximum—vigorous intensity).

Combined aerobic and resistance exercise within the same exercise session has a more favourable impact on glycaemic control than aerobic or resistance exercise alone.

Flexibility exercise recommendations
Flexibility exercises are also recommended. They complement other types of exercise and are particularly useful for older people with type 2 diabetes.

Practical implications
The guidelines of exercise prescription for patients with type 2 diabetes that were analysed in this review do not significantly differ from the exercise recommendations for the general population in the context of public health. However, the application from these guidelines should have a slow progression and, initially, patients can benefit from lower exercise volumes and intensities. Over the long term, the duration and weekly frequency of exercise sessions more than exercise type or intensity seem to affect glycaemic control.

Because patients with type 2 diabetes may be exposed to an increased risk of injury and acute adverse events during physical activity, exercise prescription for this population should also include recommendations for the prevention and control of conditions such as diabetic foot, diabetic retinopathy, diabetic nephropathy, diabetic autonomic neuropathy, cardiovascular risk, musculoskeletal disorders, hypoglycaemia, hyperglycaemia, dehydration, and the interactions between pharmacological treatment and exercise.

Patients can benefit from a pre-exercise clinical evaluation, proper planning of exercise sessions (such as the slow progression of exercise load, warm-up and cool-down periods and the pauses for hydration) and from supervised exercise by exercise professionals (who can assist with the systematic monitoring of the exercise intensity, foot observation, and regular monitoring of blood glucose and blood pressure levels, before and after exercise). These are important aspects to guarantee the safety of participants and prevent exercise-related injuries and adverse events.

Conclusions
Scientific organisations recommend the weekly accumulation of a minimum of 150 min of moderate-to-vigorous intensity aerobic activity (walking and/or jogging), spread over a minimum of 3 days a week. Resistance exercise for major muscle groups is also recommended, at least 2 days a week, and in addition to aerobic exercise. Flexibility exercises may also be prescribed, but complementarily to other types of exercise. Exercise prescription should include specific information on the type, mode, duration, intensity and weekly frequency. The exercise strategies must be adapted for each individual, based on comorbidities, contraindications and realistic personal goals.

What are the findings?

- Exercise guidelines agree on a weekly accumulation of a minimum of 150 min of aerobic exercise at moderate-to-vigorous intensity spread over a minimum of 3 days per week. Resistance exercise for muscle strengthening is also recommended at least 2 days a week. Flexibility exercises may complement other types of exercise.
- Individual exercise prescription should include specific information on the type, mode, duration, intensity and weekly frequency.
- Exercise strategies must be adapted for each individual, based on comorbidities, contraindications and realistic personal goals.

Acknowledgements The authors acknowledge the support received from all participants and researchers of the Diabetes em Movimento community-based exercise programme.

Contributors RM and NS planned the study; AA and PS conducted the bibliographic search; RM and NS organised the content; FG-M, VMR and JL-T-B reviewed the content; RM submitted the study and is responsible for the overall content.

Funding This work was conducted under Diabetes em Movimento, a clinical trial funded by Portuguese Foundation for Science and Technology (SFRH/BD/47733/2008) and registered in ISRCTN registry (ISRCTN09240628).

Competing interests None declared.

Patient consent Obtained.

Provenance and peer review Not commissioned; externally peer reviewed.

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