GOING THE DISTANCE: EXERCISE PRESCRIPTIONS FOR THE BEGINNER, INTERMEDIATE AND ADVANCED PERSON WITH DIABETES

Message from the Theme Editor:
Joanne Rinker, MS, RD, LDN, CDE

Being the Theme Editor for this exercise-focused issue of On the Cutting Edge was the perfect fit for me. As a dietitian and diabetes educator with a passion for motivating others and someone who considers herself a role model for people with diabetes and the clinicians who care for them, I wanted to jump into this issue with both feet. And so, I did!

It is amazing how many different levels of athletic ability and preparation we considered when building a list of authors who could cover the many facets of this topic. We had to consider the beginners, address those who have already started a program at some level, and work ourselves all the way up to extreme athletes with diabetes. We needed to examine exercise among people with type 1 diabetes, those with type 2 diabetes, patients with mobility issues, and those who use technology as a tool to stay motivated and keep moving.

Taking the first step toward an exercise program can be overwhelming for those who have diabetes. They’re not sure of the right time during the day to exercise; they’re uncertain about which type of exercise is right; and they may not know where to exercise, what to wear, and how often and how much to exercise. I encourage you to challenge your clients to ask themselves “when will I exercise today,” rather than “will I exercise today.”

As you read through this issue, think about not only your current but also your future clients, who have potentially vast differences in physical abilities and stages of readiness. Save this issue to reference the articles when feeling challenged by these varying circumstances. Jump in with both feet to learn something new about how to care for people with diabetes and help them safely and effectively approach exercise.

We start the issue with the latest information about a trending topic that “sitting is the new smoking!” Melanie Batchelor, MHS, RD, LDN, CDE, walks you through the consequences of sedentary behaviors, general guidelines about such behaviors, and approaches to
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Print Communications Coordinator:
Sandra Parker, RDN, CDE

NewsFLASH Editor:
Kathy Warwick, RD, CDE

On the Cutting Edge Editor:
Susan Weiner, MS, RDN, CDE, CDN

On the Cutting Edge Associate Editor:
Mary Lou Perry, MS, RDN, CDE

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Linda Flanagan Vahl
DCE Administrative Manager
Academy of Nutrition and Dietetics
120 South Riverside Plaza, Suite 2000
Chicago, IL 60606-6995
Payable to Academy of Nutrition and Dietetics/DCE noting preferred mailing address.

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Optimizing the health of people impacted by diabetes using food, nutrition, and self-management education.

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Moving to the topic of extreme athletes, Jeffery Richard, MS, RCEP, discusses the requirements for proper replacement of carbohydrates and fluids to maintain performance. He also explores the challenges of monitoring and maintaining proper glycemia for patients with type 1 diabetes during extreme athletics and how the diagnosis should not be perceived as a limitation. Finally, Rachel Head, RD, CDE, explains how children with type 1 diabetes are at increased risk for hypoglycemia during and after physical activity and how fear of hypoglycemia continues to pose barriers for families of active youths. She provides tips and strategies to prevent and, if needed, treat exercise-related hypoglycemia and to support families as they establish and maintain healthy activity habits.

Lastly, we can’t leave out technology. Sherri Isaac, MS, RD, CDE, BC-ADM, along with Lynn Grieger, RD, CDE, CPT, CWC, review many of the current exercise apps, how to find assistance with patient adherence between visits, and technology tools to keep clients motivated to stay active and improve their physical fitness.

I want to take this opportunity to thank my theme team. Delaine Wright is one of the most talented...
exercise physiologist certified diabetes educators I know. I met her in 2004 and have been learning from her ever since. I was thrilled that she was willing to take on this issue as my partner and supporter. I would also like to thank all of the authors and reviewers who were willing to write and review articles when faced with so many other responsibilities and commitments. We are all working so hard, and finding free time to write an article or review one or multiple articles takes focus, planning, and determination. Lastly, I am so honored that Susan Weiner, MS, RDN, CDE, CDN, On the Cutting Edge editor, asked me to be the theme editor for this issue. She gave me a timeline, encouraged me along the way, and stepped in at the right times to be sure we would meet our deadline. She helped this whole team produce an issue that would be beneficial for our readers, not to mention get to your doorstep on time!

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THEME TEAM
Joanne Rinker, MS, RD, LDN, CDE
Delanie Wright, MS, CDE, CEP
Susan Weiner, MS, RDN, CDE, CDN
Mary Lou Perry, MS, RDN, CDE

REVIEWERS
Maggie Birdsell, RD, CDE, LDN
Andrea Conner, MPH, RDN, CDE
Melissa Joy Dobbins, MS, RDN, CDE
Lorena Drago, MS, RD, CDN, CDE
Barbara Eichorst, MS, RD, CDE
Kathleen Fincher, MS, RD, LD
Joyce Green Pastors, RD, MS, CDE
Melissa Herman, RD, LDN,CDE
Mary Ann Hodorowicz, RDN, MBA, CDE, CEC
Ginny Ives, RD, LD, CDE, LPC
*Paula Kellogg, MS, RDN, CDE, CDN
Brenda Lee Lillard, RD, LDN, MHS,CDE
Monica McVicker, RD, LDN
Susan Meeke, MS, RD, LD, CDE
Chris Memering, RN, BSN, CDE, SANE-A
Emily Mitchell, MS, RD, CSSD, CDE
Lois Moss-Barnwell, MS, RD, LDN, CDE
Mindy Nichols, RDN, CDE
Jennifer Okemah, MS, RD, BC-ADM, CDE, CSSD
Marcey Robinson, MS, RD, CSSD, BC-ADM
Janis Roszler, MS, RD, LD/N, CDE, FAND
Gary Scheiner, MS, CDE
Hope Warshaw, MMSc, RD, CDE, BC-ADM, FAADE
Delanie Wright, MS, CDE, CEP

OTHER CONTRIBUTORS TO PRODUCTION
Linda Flanagan Vahl
Sandra Parker, RD, CDE
Marla Solomon, RD, LD/N, CDE
Lisa Trombley, MA, RD, CNSC

*Item writer for OTCE 36:4 (Renal issue)
Abstract

Despite the negative overall health outcomes associated with physical inactivity, most Americans continue to be inactive. Both lack of physical exercise and sedentary lifestyle behaviors are related to increased rates of obesity and diabetes. Independent of physical activity, though, sedentary behaviors may contribute to health risks. Sitting, especially for long periods of time, has adverse health effects. Guidelines from the American Heart Association, American Medical Association, World Health Organization, American Diabetes Association, and others suggest that exercising regularly and sitting for no longer than 90-minute intervals can improve certain health outcomes.

Introduction

The overall health benefits of physical activity, such as reduced rates of mortality, certain cancers, Alzheimer’s disease, heart disease, hypertension, stroke, and type 2 diabetes, are irrefutable. Medical professionals have touted the value of physical activity as far back as ancient China in 2600 BC and Hippocrates around 400 BC (1). Despite the evidence supporting the vast health benefits of exercise, the majority of the American population continues to miss the mark in meeting guidelines (2).

Current Guidelines and Literature Review

The Centers for Disease Control and Prevention estimates that only 49.2% of adults meet physical activity guidelines for aerobic activity and only 20.8% of adults meet physical activity guidelines for both aerobic and muscle-strengthening activity (2). This is no surprise in today’s increasingly sedentary society. The World Health Organization reported that physical inactivity is the fourth leading risk factor for mortality, accounting for 6% of deaths worldwide. They also estimated that physical inactivity was responsible for 7% of the incidence of type 2 diabetes (T2D) (3).

This article examines methods of improving physical activity and decreasing inactivity and sedentary time, reviews guidelines for positive health outcomes, examines the role of physical activity in diabetes management, and offers practical applications for health care professionals and their patients.

Recent studies have established that, independent of physical activity, sedentary time can be an indicator of negative health outcomes. Sedentary time is defined as time spent engaged in activities while sitting or lying down that require an energy expenditure of 1.0 to 1.5 basal metabolic rates. Some sedentary domains are: work, leisure, entertainment, and commuting (4). These behaviors can also be classified as nondiscretionary, such as sitting at work, or discretionary, such as watching television. According to the American Medical Association, “prolonged sitting, particularly at work settings, can cause health problems and encouraging workplaces to offer employees alternatives to sitting all day will help create a healthier workforce” (5). Health care professionals should discourage patients from being sedentary, especially sitting, for longer than 90 minutes at a time (5,6).

The key current physical activity guidelines for Americans are to:

- Avoid inactivity
- Complete at least 150 minutes per week of moderate-intensity or 75 minutes per week of vigorous-intensity aerobic activity
- Undertake aerobic activity in episodes of at least 10 minutes spread throughout the week
- Complete muscle-strengthening activities that are moderate- or high-intensity and involve all major muscle groups at least 2 days per week.
Those who have chronic diseases, such as diabetes, should complete such physical activities according to their abilities, keeping in mind safe practices and assuring they are under appropriate care of a health care professional. Medical clearance may be necessary before beginning any new physical activity (6,7).

Results from a randomized, controlled trial in the United Kingdom called Project STAND (Sedentary Time And Diabetes) suggest that implementing a patient self-management group class focusing on reducing sedentary time may decrease sedentary time and, thus, improve overall health outcomes (8). Program participants were overweight and obese young adults who had T2D.

Other investigators concluded that interventions targeting sedentary behavior should consider a “life course perspective, a position predicated on the assumption that [sedentary behavior] is age and life stage dependent” (9). They noted that environments where individuals have high exposure to sedentary behavior, such as workplaces, could benefit from certain interventions. Among their suggested strategies were computer-based prompting to stand, active workstations, policies allowing employees regular desk breaks, and encouragement of a healthy environment (such as standing meetings) (9).

Use of exercise machines in the workplace, including pedal machines and treadmills, also has been studied. Of particular note is one investigation in which researchers placed pedal exercise machines in one workplace for a total of 4 weeks (10). On average, the pedal machines were used 20 days of the 4 weeks and for approximately 20 minutes per day. Employees indicated that the pedal machines were feasible for use in the workplace and that they had an overall decrease in sedentary time related to use of the machines.

The American Diabetes Association supports the recommendations that “adults with diabetes should perform at least 150 min/week of moderate-intensity aerobic physical activity (50–70% of maximum heart rate), spread over at least 3 days/week with no more than 2 consecutive days without exercise” (11). They also encourage all individuals with diabetes to reduce sedentary time by breaking up extended periods of sitting (>60 min) and to perform resistance training, in the absence of comorbid conditions, at least twice per week (6).

**Clinical Applications**

**Increasing Physical Activity**

Clinicians can encourage their patients to establish an exercise plan following five steps recommended by the Mayo Clinic (12):

1. **Assess Fitness Level.** Assessing the person’s initial fitness ability can ensure safety and promote positive improvements over time.
2. **Design Fitness Program.** Encourage patients to consider their fitness goals, focusing on activities they may enjoy, creating a routine, planning to include a variety of activities, allowing time for recovery, and maintaining a written plan.
3. **Assemble Equipment.** Clinicians may need to assist patients in identifying needed equipment, including well-fitting athletic shoes and other supplies as needed.
4. **Get Started.** Initial tips should include starting slow and building gradually, being creative in finding opportunities for physical activity, and following any cues from the body in terms of pain or fatigue.
5. **Monitor Progress.** Encourage patients to reassess their personal fitness 6 weeks after beginning a new physical activity program and again every 3 to 6 months.

Patients need to evaluate, set, and reset goals continually, a process that can be aided substantially by help and encouragement from the clinician.

To help patients avoid feeling overwhelmed by the task at hand, which actually can discourage physical activity, clinicians should encourage patients to focus on simple steps toward becoming more active in everyday living. Among the easiest approaches are: taking the stairs rather than the elevator, parking in the back of the parking lot, walking with the family after dinner, and generally becoming more mindful about moving throughout the day. Table 1 provides a list of ideas from the American Heart Association to get moving (13).

**Decreasing Sedentary Time**

Patients can take simple steps at work to increase their physical activity (14):

1. If possible, try active commuting to work by bike or walking.
2. Keep a bottle of water at the desk, not only to ensure proper water intake but also to promote active movement when refilling the bottle.
3. Try walking meetings instead of seated ones.
4. Use lunch breaks for physical activity, such as simply taking a walk around the outside of the building.
5. Pace around the office while on a conference call.
6. Instead of emailing a coworker, get up and walk to the person to converse face to face.
7. Set an alarm for every 90 minutes to prompt standing up and moving about periodically throughout the day.
8. Consider using an active work station, such as a treadmill or pedal bike desk.

Tips for decreasing sedentary times in everyday life include (14):
1. Use a pedometer as a motivational tool to achieve a daily step goal.
2. Consider getting a pet who requires daily walks.
3. Try moving around while watching television or doing simple exercises during commercial breaks, such as crunches, squats, or push-ups.
4. Turn household chores into heart-pumping activities: vacuum with vigor or mow the lawn at a fast clip!
5. Get the whole family involved: go for a hike in the woods or play a game in a park.

Summary
Sedentary behaviors may contribute to health risks. In the United States, adults spend 55% of their waking hours in sedentary behavior (Table 2) (15–17). Adults with established T2D generally have low levels of physical activity, with step counts falling in the “low active” category, which places them at risk for disease complications and comorbid conditions such as heart disease. Sitting for long periods of time can also cause health problems. Strategies to discourage sedentary behavior can increase overall health and quality of life.

Table 2. Summary of Daily Sedentary Opportunities *

<table>
<thead>
<tr>
<th>Activity</th>
<th>Average Time Spent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commuting</td>
<td>1 hour, 30 minutes</td>
</tr>
<tr>
<td>Watching Television</td>
<td>4 hours</td>
</tr>
<tr>
<td>Working on Computer</td>
<td>8 hours</td>
</tr>
<tr>
<td>Eating Meals</td>
<td>1 hour, 15 minutes</td>
</tr>
</tbody>
</table>


Simple steps can be implemented and adopted in all community settings. Of particular importance is the workplace setting, where most sedentary time occurs. Encouraging patients to limit sedentary time to no more than 90 consecutive minutes, exercise a minimum of 150 minutes per week, and become mindfully active can reduce risks of negative health outcomes (6,7,18).

References


Abstract
Physical activity and exercise, along with meal planning and medications, are key components of diabetes management. However, the person with diabetes (PWD) faces many barriers to an active lifestyle, including physical problems that can limit mobility. Pain, balance dysfunction, and decreased joint mobility can cause functional problems, limit normal physical activity, and decrease the ability to exercise. Diabetes healthcare professionals, including nutrition professionals, can work with a PWD to determine strategies to promote physical activity and exercise and facilitate referrals to rehabilitation and exercise professionals when indicated.

Introduction
Physical activity and exercise, along with meal planning and use of medications, have long been considered key components of diabetes management. The PWD faces many barriers to an active lifestyle, including physical limitations. Physical limitations can be significant barriers as they decrease the ability to carry out exercise, reduce general physical activity, and negatively affect function. These barriers include:

- Pain
- Problems with balance
- Decreased joint mobility
- Visual disturbances
- Musculoskeletal disorders
- Vascular disease

Addressing barriers created by physical limitations can improve the ability for a PWD to perform activities of daily living (ADLs), be more physically active, and exercise regularly. The purpose of this article is to describe common physical limitations that affect mobility in a PWD and strategies for the diabetes healthcare professionals to effectively collaborate with an individual to promote physical activity and exercise.

Mobility Limitations to Physical Activity in Diabetes
The National Health Interview Survey, reported by the Centers for Disease Control and Prevention (CDC), provides the age-adjusted percentage of adults in the United States with diagnosed diabetes reporting mobility limitations from 1997 to 2011. In 2011, 36.6% reported difficulty walking one-quarter mile; 27.8% were limited in climbing up 10 steps; 38% had difficulty standing for 2 hours; and 44.3% had trouble with stooping, bending, or kneeling (Fig. 1) (1).

The percentage of people with diabetes reporting any limitation in mobility tasks increases with age. In 2011, 41.6% of those ages 18 through 44 years reported any mobility limitation compared to 61.6%, 68.9%, and 81.4%, respectively, for ages 45 through 64 years, 65 through 74 years, and 75 years or older (Fig. 2) (2).

Sinclair et al (3) conducted a population case-control study investigating the relationship between diabetes and functional impairment in older people. Those with diabetes had more comorbidities and were more likely to have severe functional mobility impairments compared to controls. The association between diabetes and mobility limitation remained when age, hypertension, cerebrovascular disease, chronic obstructive pulmonary disease, cancer, osteoarthritis, and dementia were controlled (3). Data from the Third National Health and Nutrition Examination Survey documented that older adults (>60 years) had a higher prevalence of disability associated with diabetes than those without diabetes (4). This included a two- to threefold decreased ability to walk one-quarter mile, climb 10 steps, and do housework (4). Lower extremity (LE) function was assessed in disabled older women in the Women's Health and Aging Study to determine the role of diabetes-related impairments and comorbidities in physical disability (5). Women with diabetes were more likely to have comorbidities, mobility disability, ADL disability, severe walking limitation, and lower scores of mobility performance (slower walking speed, decreased LE (lower extremity) strength, and decreased balance).
Visual impairment also can decrease function and physical activity. In 2011, 4 million adults with diabetes reported visual impairment (trouble seeing even with glasses or contact lenses) (6).

Problems that can negatively affect movement must be addressed when working with an individual to increase the ability to perform ADLs, improve function, and promote an effective exercise program. During the diabetes self-management education and training process (DSME/T), the clinician should obtain a complete history, which includes pain (body region, intensity, and impact on activity) and an assessment of other physical limitations such as decreased range of motion (ROM), balance dysfunction, and visual impairment. If a person has impairments that limit physical activity, referral to a physical therapist (PT), occupational therapist (OT), certified exercise professional, or low-vision specialist/blindness professional may be warranted.

**Limitations to Physical Activity Associated with Pain**

Mobility limitations can be related to a combination of factors, including pain. The many sources of pain that are common in a PWD encompass musculoskeletal (e.g., arthritis), neurogenic (e.g., neuropathy), and vascular (e.g., intermittent claudication) conditions. In a study by Krein and colleagues (7) that included 993 patients with diabetes at the Department of Veterans Affairs, approximately 60% of participants reported having chronic pain (present most of the time for 6 months or more during the past year). The most common sites of pain were the back, hip, and knee. Those with chronic pain had a higher body mass index, were

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**Figure 1. Age-adjusted percentage of adults with diagnosed diabetes reporting mobility limitation, by task, United States, 1997-2011.**


**Figure 2. Percentage of adults with diagnosed diabetes reporting any mobility limitation, by age, United States, 1997–2011.**

younger, and reported that their health was fair or poor. Pain was significantly associated with poorer diabetes self-management \( (P=0.002) \), including ability to exercise and follow a meal plan. Taking pain medications created some improvement in the ability to manage diabetes but not to the level of those without chronic pain \( (7) \).

In a large outpatient urban diabetes care and education program, pain was the most commonly reported barrier to exercise, with 41% of 605 participants (average age 50 years) reporting this as a barrier \( (8) \). Those participants who reported a barrier exercised less frequently (3 vs. 4.2 days/week) and for shorter duration per session (33 vs. 58 minutes/session) compared to those who did not report a barrier. Walking outdoors was preferred by 89% of the exercisers who reported a preference, and 74% reported walking outdoors as the most common favorite leisure-time activity \( (8) \). Walking is commonly limited by pain, specifically when pain is in the back, hips, or knees. A PWD who is experiencing pain may benefit from alternative forms of exercise and leisure-time activities that do not increase pain.

**Diabetes, Arthritis, and Physical Activity Limitations**

The CDC reported the relationship among diabetes, arthritis, and physical activity. In the Behavioral Risk Factor Surveillance System, an epidemiologic study involving more than 800,000 United States adults, the reported prevalence of arthritis in those with diabetes was 52% \( (9) \). Physical inactivity was higher among adults with diabetes and arthritis (29.8%) compared with adults with diabetes alone (21.0%), an association that was independent of age, sex, or body mass index. Arthritis was determined to be a potential barrier to physical activity among adults with diabetes \( (9) \).

There is a strong association between osteoarthritis (OA), specifically of the knee, and diabetes. Because obesity is a risk factor for type 2 diabetes (T2D) and for OA, the increased occurrence of OA with diabetes is likely primarily due to obesity. Overweight adults have a sixfold increase in the incidence of unilateral knee OA and an 18-fold increase in the incidence of bilateral knee OA compared to normal-weight controls \( (10) \). Furthermore, those who are obese and have knee OA have decreased walking and aerobic capacity and quality of life compared to those who are obese but without OA \( (11) \). However, the pain and disability from OA can improve with a weight loss of greater than 5% \( (12) \). Strategies that promote modest weight loss may have a positive impact on diabetes control as well as a potential decrease in LE pain and improved physical function.

**Musculoskeletal Disorders of the Shoulder and Hand and Activity Limitations**

Both people with type 1 diabetes (T1D) and those with T2D have an increased incidence of musculoskeletal disorders (MSDs) involving connective tissue that can result in decreased ROM and pain at the shoulder and hand. Common MSDs include adhesive capsulitis (frozen shoulder), flexor tenosynovitis, “trigger finger,” carpal tunnel syndrome and, less commonly, stiff hand syndrome. Cagliero et al \( (13) \) studied the incidence of MSDs in those with T1D and T2D compared to controls. MSDs were about four times more frequent in PWDs compared to controls. The PWDs who had MSDs were more likely to be female, have a longer duration of diabetes, and have retinopathy, nephropathy, or neuropathy when compared to PWDs who did not present with MSDs \( (13) \).

Pain and decreased ROM in the shoulder or hand can affect a person’s ability to dress, prepare food, and exercise (e.g., resistance training in the upper extremities and some sports). Referral to an OT or PT may be indicated if an individual has functional limitations due to MSDs of the shoulder or hand.

**Neuropathic Arthropathy of the Foot and Activity Limitations**

Diabetic osteoarthropathy (also called Charcot joint or Charcot or neuropathic arthropathy) is a progressive, destructive arthropathy that develops in an area of sensory loss due to peripheral neuropathy. Charcot foot is rare but can have severe consequences due to the increased risk of open wounds in the area of the foot deformity. Early diagnosis and prevention are critical to avoid future complications. Immediate relief of pressure with a custom-fitted walking boot and rest can limit deformity of the area and damage to the skin and underlying tissues \( (14) \). An exercise prescription should be provided by a PT or certified exercise professional that involves nonweightbearing activities such as swimming and resistance training without weightbearing through the foot.

**Neuropathy Related Limitations to Physical Activity**

A PWD may have decreased function due to neuropathy, which can cause...
pain in the feet and/or balance dysfunction. Chronic sensorimotor distal symmetric peripheral neuropathy is the most common form of neuropathy in diabetes, with up to 50% of PWDS reporting symptoms of burning pain, stabbing or electrical sensations, hyperesthesia, paresthesia, or a deep aching pain (15). In a randomized, controlled trial of patients with diabetes and neuropathy, Allet and colleagues (16) compared patients receiving an exercise intervention to a control group not receiving an intervention. The exercise intervention was carried out twice a week for 60 minutes over 12 weeks and included physiotherapist-led group exercises of a warm-up, circuit training with gait and progressively challenging balance exercises, and interactive games. After completion of the training, the intervention group increased walking speed, balance, mobility, and LE strength and decreased fear of falling compared to the control group (16). If a PWD has functional limitations due to neuropathy, referral to a PT, OT, or evidence-based balance exercise program may be indicated to improve balance and function.

Lower Extremity Vascular Disease Related Limitations to Physical Activity
Peripheral arterial disease (PAD), a vascular condition characterized by LE atherosclerotic occlusion, can cause symptoms of intermittent claudication such as pain, cramping, or aching in the calves, thighs, or buttocks that increases with walking and is relieved with rest (17). It is common for a person to decrease activity, specifically walking for exercise or ADLs, when pain from PAD starts. However, a systematic review of the evidence for the effectiveness of exercise therapy for PAD demonstrated that supervised exercise training compared to standard care increased pain-free walking distance (PFWD) and absolute walking distance (AWD) by 81.3 m (266.7 ft) and 155.8 m (511.2 ft), respectively (18). In the comparison of supervised and unsupervised exercise, both groups showed improvements, with an increase in PFWD of 143.81 m (471.8 ft) and in AWD of 250.40 m (821.5 ft). Most studies involved exercise two to three times per week, some with an intensity of near maximal pain (18). If a PWD is limited in walking tolerance due to PAD, an exercise program may prove beneficial in increasing both PFWD and AWD. The person must be educated about the benefits derived from walking to nearly maximal pain levels.

Balance Related Limitations to Physical Activity
Older PWDS have an increased risk of falls, including injurious falls. Among the many known risk factors for falls for a PWD are decreased sensory input from peripheral neuropathy, LE pain, decreased physical performance/LE strength, decreased cognitive performance, visual disturbances, increased use of medications (including antidepressants), and hypoglycemic episodes (19). An analysis of participants in the Health ABC Study, a prospective longitudinal study, reported the following factors among PWDS that were associated with an increased incidence of falls resulting in a hospital admission: older age, female sex, a history of a fall in the past 12 months, decreased LE strength, impaired standing balance performance, poor glycemic control (hemoglobin A1c ≥8%), and longer duration of diabetes (19).

Many individuals with diabetes and balance dysfunction may understand that they have a problem but not realize that balance can be improved with interventions. Because of this misunderstanding, they may limit activities that can cause a fall or carry out activities and experience near-falls or falls. If a PWD has balance dysfunction, appropriate referrals may be to an evidence-based community balance program (including tai chi), a certified exercise professional, or an OT or PT for rehabilitation, which may include instruction in the use of an assistive device to improve safe mobility.

Osteoporosis and Diabetes
Osteoporosis is defined as a disease “characterized by low bone mass, deterioration of bone tissue and disruption of bone architecture, compromised bone strength, and an increase in the risk of fracture” (20). The incidence of osteoporosis in those with T1D has long been recognized. Tuominen and colleagues (21) reported that adult men and women with T1D have lower bone density compared to those with T2D and controls, and women with T1D have a higher incidence of low-trauma fractures than women with T2D. In the Iowa Women’s Health Study, a prospective cohort of more than 32,000 postmenopausal women, women with T1D were 12.25 times more likely to report an incident hip fracture when compared to women without diabetes (22).

There is also a positive correlation between those with T2D and fracture (22) despite having a normal or greater-than-normal bone density (21). Postmenopausal females with T2D in the Iowa Women’s Health Study had a 1.7-fold higher risk of hip fracture.
fracture than those without diabetes, and the incidence increased with duration of diabetes (22). The Study for Osteoporotic Fractures found an increased incidence of hip, proximal humerus, and foot fractures in women older than age of 65 with T2D compared to women of the same age without diabetes, suggesting that diabetes as a risk factor for fracture despite higher bone density at the hip, wrist, and heel (23). The increase in fractures among those with T2D is likely due to many factors. Because bone density has been shown to be normal or increased in those with T2D compared to controls, poor bone quality combined with an increased risk of falls may increase fracture incidence.

Clinicians must consider the possibility of osteoporosis and risk of falls and fractures when evaluating a person with T1D or T2D and include referrals for the prescription of safe and effective exercise to promote improved bone density, balance, posture and body mechanics, and education on safe movements to avoid fractures.

Clinical Application
The specifics of an exercise prescription for a person with T2D are described in the Joint Position Statement of The American College of Sports Medicine and the American Diabetes Association (24) and are summarized in another article in this issue of On The Cutting Edge (page 15). Several categories of exercise are included in the recommendations, including aerobic exercise, resistance training, flexibility training, balance training, and nontraditional types of training (e.g., tai chi and yoga).

Physical limitations must be taken into account when prescribing exercise for a PWD. The many possible options for aerobic exercise can be weightbearing or nonweightbearing. Walking is a common choice for aerobic exercise but may not be possible for a person with physical limitations. Sitting exercise, aquatic exercise, and low-impact exercises performed with or without equipment may be viable options if physical limitations prevent other forms of aerobic exercise. Shorter duration, starting with a goal of 10-minute sessions, and a slower progression of exercise may be necessary to improve long-term success.

Resistance training can be a valuable component of the exercise program, specifically if weightbearing is not well tolerated. When performed correctly, resistance training can be safe and effective and may decrease an individual’s physical limitations, improve ADLs and overall function. A combination of aerobic and resistance exercise is also an excellent option to provide benefits without overly stressing any particular area.

Flexibility should be prescribed to address specific areas of decreased mobility, notably in a person with MSDs causing ROM impairments that negatively affect function. Patients should be referred to a PT, OT, or certified exercise professional for safe and effective stretching exercises.

Balance training, including LE strength training and challenging balance activities, can improve balance, decrease the risk of falls, and improve function in a PWD who has balance dysfunction. The person who demonstrates balance impairment or reports a fall in the past year should be referred to a PT, OT, certified exercise professional for safe and effective stretching exercises.

Summary
PWDs may be restricted in physical activity and exercise because of physical limitations. A nutrition professional has an opportunity to facilitate improved physical activity and exercise for a PWD through the DSME/T process by inquiring about the individual’s current physical activity or exercise program and physical limitations that may be interfering with activities. If the PWD has pain, balance dysfunction, or decreased ROM affecting function and physical activities, referral to a PT, OT, or certified exercise professional may be needed. For a person with visual impairment, referral to a low-vision specialist/blindness professional may also be indicated. Balance can be improved through specific exercises prescribed by a rehabilitation professional or through group exercise classes offered in the community, including tai chi. Education by the nutrition professional regarding the possibility for improvement of function, physical activity, and exercise for the PWD who has physical limitations can be invaluable.

Case Study
AH is a 58-year-old female who was diagnosed with T2D at the age of 32 years. She is of Latino descent and has a family history of T2D. She has used insulin for 15 years and currently is on a regimen of multiple daily injections (basal and bolus). Her recent hemoglobin A1c was 8.8%, and her body mass index is 32.5. She has sensorimotor distal symmetric peripheral neuropathy, peripheral arterial disease, hypertension (well-controlled with an angiotensin-converting enzyme inhibitor and a beta-blocker), dyslipidemia (well-controlled with a statin), coronary artery disease, and depression. She is limited to walking a half block due to pain and cramping in both lower legs and pain in both feet, likely from...
intermittent claudication. She reports pain in the right shoulder when reaching forward, dressing, and lifting overhead, which started 1 year ago without incident. She also notes that her balance is not good and that she fell once in the past year when she slipped on a wet tile floor. She did not sustain injuries that required medical care. She was very active in her youth and through her young adult life. She would like to increase her exercise to improve her ability to walk and to carry out house and yard activities with less fatigue and pain as well as to improve her blood glucose levels and general health. She has tried going to a gym in the past but stopped due to an increase in her lower leg and right shoulder pain with exercise. She has been referred to a nurse educator, registered dietitian/nutritionist, and a physical therapist for diabetes self-management education. Her recommended exercise prescription, created with the physical therapist is in the Table.

Table. Exercise Prescription for AH

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Frequency</th>
<th>Intensity</th>
<th>Type</th>
<th>Time/Duration</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic exercise</td>
<td>3-5 days/wk</td>
<td>Moderate intensity</td>
<td>Continuous activities that limit the onset of lower extremity (LE) symptoms, including stationary cycling, recumbent stepper, swimming/water walking/aquatic exercise, and walking on land (treadmill or track), as tolerated based on LE pain.</td>
<td>Goal of 150 total min/wk with 30-45 total min/session in bouts of 10 minutes as needed, based on pain</td>
<td>Exercise to highest tolerable LE pain level; avoid shoulder pain; use a variety of exercises to change stress to painful areas; monitor cardiovascular symptoms and pain. Do not perform vigorous aerobic exercise unless cleared by physician due to cardiovascular risk factors.</td>
</tr>
<tr>
<td>Resistance training</td>
<td>2-3 non-consecutive days/wk</td>
<td>Initially 10-15 repetitions to fatigue, progressing to higher resistance to allow for 8-10 repetitions to fatigue</td>
<td>Free weights, resistance machines, or calisthenics using body weight as resistance</td>
<td>Start with 1 set and progress to 3-4 sets of 5-10 exercises that work the major muscle groups of the upper extremities, LEs, and trunk</td>
<td>Avoid exercises that cause shoulder or LE pain. Use comfortable breathing through exercise without holding breath. Resistance training can help to improve function with less LE pain than brought on during LE aerobic exercise such as walking.</td>
</tr>
<tr>
<td>Balance training</td>
<td>Daily home exercises</td>
<td>Challenging enough to cause moderate imbalance without risk of falling; advance exercises as balance improves</td>
<td>Static balance exercises (e.g., tandem stance progressing to single-limb stance) and dynamic balance exercises (e.g., walking in a hallway as if on a tightrope)</td>
<td>Total of 5-10 min/day</td>
<td>Stand with back in a corner for safety during static exercises; walk in a narrow hallway for safety during dynamic exercises</td>
</tr>
<tr>
<td>Flexibility training</td>
<td>Individually prescribed for right shoulder and LEs (specifically calf/Achilles tendon) as needed based on evaluation of range of motion. The intensity should be to a feeling of mild discomfort; never into pain.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharge Plan</td>
<td>Following a course of physical therapy, AH will be referred to a local fitness facility to continue the safe and effective aerobic and resistance training exercise program established in physical therapy and will perform balance and stretching exercises at home. Foot care guidelines for daily foot checks and appropriate footwear (socks and shoes) will be included in her education.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


People with T2D are less likely to meet the current recommendations for physical activity than people without diabetes, which demonstrates a need for more efforts from all health care professionals to promote physical activity in this population (1). Management of T2D can incorporate a variety of physical activities, including simply moving more every day. To implement strategies that can help individuals with T2D make appropriate and lasting lifestyle changes, the nutrition professional needs to understand the exercise recommendations, motivational factors leading to behavior change, and potential obstacles to lasting lifestyle management. In addition, it is important to understand necessary exercise precautions.

By way of example, 1 hour of low-intensity exercise substantially reduced the prevalence of hyperglycemia during the next 24 hours in individuals with T2D, whereas 30 minutes of high-intensity exercise did not, demonstrating that daily living activities, which frequently are performed at a lower intensity, likely have a positive impact on blood glucose control (3). Although increased lifestyle activity usually cannot entirely take the place of a structured exercise program, it can be highly effective for building a fitness base that can allow individuals to participate in subsequent more intense or structured activities (4).

The latest research has focused on the metabolic effects of simply reducing sedentary time and breaking up long bouts of sitting with physical movement. A strong association between engaging in sedentary behaviors and higher blood glucose concentrations has been reported in adults with T2D (5), and breaking up prolonged sitting lowers glycaemia, even in adults without T2D (6,7). In their latest diabetes management recommendations, the American Diabetes Association recommends that all people take a physical activity break after 90 minutes of sedentary activities to improve metabolic health (8).
Aerobic Exercise Training

Exercise Type
Any type of aerobic exercise is likely to benefit blood glucose concentrations and cardiovascular risk management in individuals with T2D, but undertaking a variety of physical activities is recommended to optimize training effects and reduce the risk of developing overuse injuries (9). Acceptable aerobic activities include both weightbearing and nonweightbearing ones, such as walking, jogging, cycling, swimming and other aquatic activities, conditioning machines, dancing, chair exercises, and rowing. Walking and moderate-intensity physical activities are associated with a very low risk of musculoskeletal complications, whereas jogging, running, and competitive sports are associated with increased risk of injury (Table 1) (4).

Exercise Intensity
Recommended aerobic exercises are typically moderate or vigorous in intensity. Using subjective ratings, moderate exercise corresponds to an overall body rating of “somewhat hard” and “vigorous to hard” (4). Less fit people require a higher level of effort to complete the same activity, and their initial subjective intensity may need to be lower than “somewhat hard.”

For most people with T2D, brisk walking is considered a moderate-intensity exercise due to their lower cardiorespiratory fitness capacity. Those who only can complete low or moderate exercise should include faster intervals of any duration and intensity in their regimen to achieve greater fitness gains and cardiovascular protection. Intervals can be as simple as periodically walking faster between two points during a moderate bout of activity or more structured, such as doing 60 seconds of high-intensity work followed by a similar amount of rest, with the sequence repeated up to 10 times. Likely, the total volume of exercise (i.e., intensity, duration, and frequency) is more important than intensity alone for cardiovascular risk reduction in this population (10). However, adults who are already sufficiently fit to exercise at a moderate intensity should undertake vigorous activity, at least on occasion, to obtain additional glycemic and cardiovascular benefits (11).

Exercise Frequency
Ideally, adults with T2D should engage in aerobic exercise at least 3 days per week, with no more than 2 consecutive days between sessions (9). Current guidelines for adults generally recommend five sessions of moderate activity (12,13). When participants with T2D do either 30 minutes of daily, moderate-intensity aerobic activity or 60 minutes of similar-intensity exercise every other day, the glycemic effects are comparable, as long as the total amount of work is the same (14). The recommended frequency, therefore, is a minimum of 3 to 5 days per week, with equal energy expenditure regardless of how many days of physical activity are undertaken for optimal health management.

Exercise Duration
Individuals with T2D should engage in a minimum of 150 minutes per week of exercise undertaken at moderate intensity or greater (9). Aerobic activity should ideally be performed in bouts of at least 10 minutes at either intensity to promote greater endurance and overall fitness, although some may need to begin with shorter sessions.

Exercise Progression
Deconditioned individuals should begin at a lower intensity and gradually progress exercise volume to minimize the risk of injury or demotivation. Initially, they should increase the frequency and duration of the exercise rather than intensity. Progression over 4 to 6 months may include vigorous aerobic exercise, but moderate-intensity workouts may be an appropriate endpoint for adults with T2D (although frequency and duration may progress over time) (9).

Training Precautions
Previously sedentary individuals with T2D do not require a medical evaluation before participation in physical activities that are no more intense than brisk walking, unless they have cardiovascular or other diabetes-related health complications. However, anyone wishing to engage in vigorous activities may benefit from a physical examination and possible exercise stress test before initiating such training (9).

Resistance Training
Resistance (strength) training improves musculoskeletal health, enhances the ability to perform activities of daily living, and lowers the risk of injury from falls and descent into frailty (4,12,13). For people with diabetes, resistance training can additionally improve glycemic control, as least as much as aerobic training. In one investigation, 16 weeks of twice-weekly progressive resistance training in older men with new-onset T2D resulted in a 46% increase in insulin sensitivity, 7% reduction in fasting blood glucose, and loss of visceral fat, all while consuming a 15.5% average higher energy intake (15). When combined with moderate weight loss, resistance training is more effective for
improving overall glycemic control than moderate weight loss alone and prevents muscle mass loss (16). More recently, resistance training was found to improve metabolic parameters, such as overall glycemic control, levels of adiposity, and waist circumference, even in individuals with T2D who failed to exhibit improved cardiorespiratory fitness with such training (17).

**Exercise Type**
Resistance exercises should involve the major muscle groups in the upper body, lower body, and core, including the back, legs, hips, chest, shoulders, arms, and abdomen (4,9,12). Any resistance exercises can be performed alone or in combination to improve muscular strength and endurance, including free weights (dumbbells and barbells), weight or resistance machines, resistance bands, isometric exercises, and use of body weight as resistance (4).

**Exercise Intensity**
A wide range of intensities in resistance training improve overall glycemic control and cardiovascular risk in individuals with T2D (10). The total volume of resistance training (resistance used and number of repetitions and sets) is likely more important than either degree of resistance or number of repetitions. Accordingly, when using lower resistance, individuals should complete a higher number of repetitions to equal the total exercise volume of high intensity (higher resistance, lower repetition) training.

**Exercise Frequency**
Training should be undertaken at least twice weekly on nonconsecutive days (with a minimum of 48 hours between sessions) (4,9,12,13). Three times a week is ideal (16) in conjunction with regular aerobic exercise and daily lifestyle activity. If a person wants to engage in resistance training more than 3 days per week, he or she needs to alternate the muscles trained from one day to the next (e.g., focusing on lower body and back exercises in one workout and upper body and abdominals the next) to give specific muscle groups at least 48 hours of recovery time for optimal strength gains and injury prevention.

**Exercise Duration**
No specific amount of time or total volume of exercises is recommended for muscle strengthening. At least 5 to 10 exercises involving the major muscle groups in the upper body, lower body, and core should be included, and each should be performed to the point at which it is difficult to do another repetition without assistance during the final set. One to four sets per exercise session may be included (4).

**Exercise Progression**
Individuals who start with a goal of completing 10 to 15 repetitions to near fatigue per set early in training should ideally progress over time to using heavier weights or resistance that can be lifted only 8 to 10 times. This increase in resistance can be followed by a greater number of sets and finally by increased training frequency to avoid injury (4). Individuals with joint limitations or other health complications should complete one set of exercises for all major muscle groups, starting with 10 to 15 repetitions and progressing to 15 to 20 repetitions before adding more sets (13).

| Table 1. Structured Exercise Recommendations for Adults with Type 2 Diabetes |
|---------------------------------|---------------------------------|---------------------------------|
| **Aerobic Exercise**            | **Resistance Exercise**         |                                  |
| **Type**                        | Continuous activities using the large muscle groups, e.g., walking, cycling, swimming, cross-country skiing, and aquatic exercise | Free weights, weight or resistance machines, resistance bands, isometric exercises, or calisthenics using body weight as resistance |
| **Intensity**                   | Moderate to vigorous (low intensity to start if severely deconditioned) | Light, moderate, or vigorous |
| **Frequency**                   | Minimum of 3 nonconsecutive days per week, with additional benefits likely from 5 or more days, and no more than 2 consecutive days without aerobic activity | At least 2, but more ideally 3, nonconsecutive days per week |
| **Duration**                    | Minimum of 150 minutes spread throughout the week (minimum of 10 minutes per session, with 30 or more as a goal), possibly a lower total time if done more intensely | 1 to 3 sets of 8 to 15 repetitions per set, including at least 5 to 10 exercises that work the major muscle groups |
| **Progression**                 | Progress over period of 4-6 months, increasing frequency and duration of the exercise first and intensity last | 1 set of 10 to 15 repetitions to fatigue initially, progressing to 8 to 10 harder repetitions, and finally to 3-4 sets of 8 to 10 repetitions to fatigue |
Training Precautions
Although moderate- to high-intensity resistance training does not induce ischemia, resistance exercises should be dynamic and participants should not hold their breath. Anyone with unstable proliferative retinopathy (diabetic eye disease) or severe nephropathy (kidney disease) should likely refrain from resistance training due to an excessive systolic blood pressure response that could exacerbate those conditions (9). Anyone with health complications that may be worsened by resistance training should seek guidance from a health care professional before starting.

Combined Aerobic and Resistance and Other Types of Training

Combined Aerobic and Resistance Training
Some investigators have examined the glycemic benefits of combined aerobic and resistance training programs (18,19). A meta-analysis showed that structured aerobic, resistance, or combined exercise training is associated with a hemoglobin A1c decrease of 0.67% following 12 or more weeks of training (18). Exercise training that exceeded 150 minutes per week, whether aerobic, resistance, or a combination of the two, was associated with greater glycemic benefit than doing less than that amount per week, but any type of training caused greater declines in glycemic levels than simply giving people physical activity advice.

Flexibility Training
Flexibility training 2 to 3 days (or more) per week is recommended, but it should not substitute for other recommended activities (i.e., aerobic and resistance training). Whether stretching is static or dynamic, such training does not usually have much of an impact on glucose control, body composition, or insulin action. In general, stretching is more effective after a warm-up period or at the end of an exercise session rather than before starting to exercise.

Balance Training
Lower body and core resistance training doubles as balance training. Many balance exercises can be undertaken to lower an individual's risk of falling, even when peripheral neuropathy (nerve damage in the feet) is present.

Other Types of Exercise Training
Less commonly prescribed exercises such as tai chi and yoga may also be effective in promoting better balance, strength, and flexibility (20). Culturally or socially accepted activities such as dance (ballroom, salsa, tango, or Zumba) may also be appropriate choices to increase exercise participation.

Lifestyle Interventions
Most American adults with T2D do not engage in regular physical activity (21). Large-scale trials such as the Diabetes Prevention Program and Look AHEAD (Action for Health in Diabetes) involved successful lifestyle interventions that helped promote physical activity with goal-setting, self-monitoring, frequent contact, and stepped-care protocols. These studies targeted a number of behaviors, including physical activity, diet, and weight loss. Evidence, knowledge, and insights gained from these trials can aid in determining the strategies needed to apply their findings in real-world settings to prevent and manage T2D (22).

Exercise Adoption and Maintenance
To promote behavior change, health care professionals must address effective approaches to increasing both the adoption of exercise and its long-term maintenance. Effective short-term programs and education have been delivered successfully in print, in person, and via the Internet, although their long-term effectiveness has not been assessed (23).

Affective responses to exercise may be important predictors of adoption and maintenance, and encouraging activity at a low-to-moderate intensity may be most beneficial. Sedentary adults who reported more positive affective responses to a moderate-intensity stimulus during a single bout of exercise reported more minutes of physical activity 6 and 12 months later (24).

The many adults with T2D who walk for exercise may be able to use pedometers (step counters) to increase physical activity (25) as well as accelerometers, mobile apps, and other features related to the latest “smart” technologies. Participation in supervised physical activity should be encouraged during initial phases of an exercise program to aid in monitoring exercise responses and blood glucose levels. Simply allowing individuals to exercise at an intensity that “feels good” may promote greater adherence (26). Future interventions may incorporate strategies that simply decrease sitting time and extended sedentary periods (27).

Clinical Application
Although traditional focus has been on structured exercise, the finding that breaking up sedentary time can improve physical function (27) suggests that greater participation in activities of daily living may be an appropriate starting point, especially for deconditioned individuals newly diagnosed with T2D. To incorporate
more structured physical activities of all types, other strategies can be employed to promote long-term exercise adherence, including effective goal-setting and use of social support networks.

**Promotion of Exercise Adherence**

Overcoming barriers that interfere with a more physically active lifestyle is a critical part of effective diabetes management, especially when health complications create challenges to being active. Certain physical movements may also pose safety issues, and not all individuals are capable of participating in or willing to start a fitness program, regardless of the health benefits.

Efforts to promote physical activity should focus on developing individuals' self-efficacy (or their belief that they can exercise) and fostering social support from family, friends, and health professionals. Inactive older adults, in particular, may be intimidated by fitness facilities and concerned about slowing down others in a group exercise setting. Thus, seeking out alternate venues and activities could increase their participation (28). Such people should be encouraged to invite friends and family to join in their activity and to use social interactions to promote greater adherence. An exercise buddy can increase a person's motivation to exercise. Even having a dog that needs to be walked regularly promotes greater activity, raises fitness, and increases the likelihood that the activity will continue over time.

Engaging in mild or moderate activities (as opposed to more intense ones) may be the most beneficial step to adoption and maintenance of regular participation in individuals with T2D. Enjoyment of physical activity, lack of perceived barriers to being physically active, positive beliefs about health benefits, support from others to exercise, and cultural beliefs and practices are also critical to promotion of exercise adherence. One technique that nutrition professionals can use is to steer patients toward activities they enjoy. Ask individuals about what types of activities they have done in the past and how they felt about them. Reiterating the positive impact of moderate exercise or even increased daily activity on patients' glycemic control, blood pressure, and overall health can be another good motivator.

Behaviorally based interventions, use of behavior change strategies, a supervised setting, and exercise that is enjoyable can improve adoption and adherence (4). The availability of facilities, pleasant places to walk, and economical exercise options are also important predictors of regular participation. Physical activities programs may be available at local community or senior centers, fitness facilities, or places of employment. Affordable activities, such as group walks, can promote adherence by increasing the social aspect of the activity and lowering barriers to participation. Walking indoors in local malls and other public venues is a possibility when the weather is inclement.

**Effective Goal Setting for Motivation**

Individuals who are planning to increase and maintain physical activity must set realistic and practical short-term goals. Nutrition professionals should encourage individuals to plan out their specific exercise participation, track their goals, and identify potential barriers when setting physical activity goals that are SMART: Specific, Measurable, Attainable, Realistic, and Timeframe-specific (Table 2).

**Social and Professional Support**

In one investigation, people with diabetes received physician advice or referral related to exercise at an average 18% of office visits, with 73% reporting that they received advice to exercise more (21). Such advice is associated with better glycemic control only when combined with dietary advice, but not when given alone, which is where the nutrition professional can play a pivotal role (18). Counseling delivered by nutrition professionals is a meaningful and effective source of support. Even peer mentoring may enhance diabetes management and adoption of healthier lifestyle habits. Diabetes-related social media and online support groups may provide yet another effective avenue for lasting physical activity behavior change.

<table>
<thead>
<tr>
<th><strong>Specific:</strong></th>
<th>Set goals that are as precise as possible when identifying details of frequency, duration, intensity, and type of activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurable:</strong></td>
<td>Make goals that can be quantified so that individuals can accurately track, measure, and identify progress</td>
</tr>
<tr>
<td><strong>Attainable:</strong></td>
<td>Set goals that are challenging but reachable to increase confidence and the likelihood of setting even more challenging goals in the future</td>
</tr>
<tr>
<td><strong>Realistic:</strong></td>
<td>Evaluate how likely individuals are to attain their chosen goals in a given situation</td>
</tr>
<tr>
<td><strong>Timeframe-specific:</strong></td>
<td>Set short-term goals that provide more immediate feedback, such as setting ones for just the next week</td>
</tr>
</tbody>
</table>
Summary
Adults with T2D can undertake a wide variety of physical activities to improve their glycemic control and lower cardiovascular risk. Recommended options include aerobic, resistance, combined, nontraditional, and other types of training. Additional strategies are needed to increase the adoption and maintenance of physical activity, which is a critical and effective blood glucose management tool for T2D. Nutrition professionals should encourage individuals with diabetes to plan out their specific exercise participation, track their goals, and identify and troubleshoot potential barriers. Exercise and lifestyle advice delivered by such professionals may be another meaningful and effective source of support, along with use of social support networks and effective goal-setting.

References
17. Pandey A, Swift DL, McGuire DK, Ayers CR, Neeland IJ, Blair SN, Johansson N, Earnest CP, Berry JD, Church TS. Metabolic Effects


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**CPE CREDIT ANSWER KEY**

See the CPE credit self-assessment questionnaire on page 41.

1. C  
2. A  
3. B  
4. A  
5. D  
6. C  
7. A  
8. D  
9. D  
10. C
Abstract
Physical activity is a crucial component of diabetes self-management. Running has become a favored form of physical activity for many of those with diabetes, who frequently compete in 5-K and 10-K runs. Running has many clinical benefits for those with diabetes and can be done safely when the proper precautions are taken.

Introduction
Running has been shown to increase cardiovascular health, lower blood glucose values, and potentially decrease the need for medication in those who have diabetes (1). Registered dietitian nutritionists (RDNs) should be prepared to address potential challenges that runners who have diabetes may encounter during training or racing and help them to engage safely in this physical activity. The RDN should make a full assessment of the individual before he or she engages in a running plan. Such assessment should include review of food intake, training level, medication review, personal goals, and time of day of the run. This article focuses specifically on these issues and the physiologic response during running for the person who has type 2 diabetes (T2D).

The Effect of Running on Blood Glucose Concentrations
Blood glucose concentrations generally remain stable in individuals due to the interplay among liver glycogenolysis (release of glycogen from the liver in the form of glucose), gluconeogenesis (glucose produced from noncarbohydrate substrates), and alternate fuels such as free fatty acids. However, running intensity and duration can cause a shift in the predominant energy source, thereby affecting blood glucose levels (2).

During running, plasma insulin levels decrease and plasma glucagon is released, which increases hepatic glucose production and raises glucose concentrations in the bloodstream. Muscles are prompted to absorb excess glucose circulating in the bloodstream, allowing for the availability of blood glucose for immediate energy to the working muscles. As the activity continues, the plasma glucagon and catecholamine, acting as counter-insulin hormones, play vital roles in stabilizing blood glucose concentrations by releasing glucose from glycogen stores (2).

Runners experience reduced insulin-stimulated blood glucose uptake because of a mutation in the Glut-4 gene (translocation impairment) that is specifically related to T2D (3). The translocation of Glut-4 receptors that occurs in T2D aids in blood glucose control by improving insulin sensitivity. The combination of increased insulin sensitivity and glucose uptake via muscles can affect blood glucose stability.

Exercise Factors Influencing Blood Glucose Stability
Medication adjustments are based on the timing, duration, and intensity of the running activity as well as training adaptations. RDNs first must review the potential impact of the runner’s medications on blood glucose stability and then consider how training factors may further affect blood glucose.

Glucose-lowering Medications and Exercise
Runners with diabetes must closely monitor their blood glucose before, during, and after their runs to make necessary adjustments in food and carbohydrate intake or glucose-lowering medication. If their running schedule is unpredictable or erratic, medication adjustments may not be the best option; instead, the RDN may want to teach the person with T2D how to adjust the amount of carbohydrate consumed during and after the run (4). For example, if a person has an unexpected afternoon break in her work schedule that allows her to pursue her training, but she took insulin lispro 2 hours ago with her lunch, she may want to drink a carbohydrate-containing beverage before and during exercise to prevent hypoglycemia while closely monitoring her blood glucose (5).
**Timing**

Running in the morning, afternoon, or evening can affect the body’s response to that activity. Those who prefer to exercise midday at a moderate intensity may be prone to nocturnal hypoglycemia up to 11 hours after exercise due to increased glucose uptake in muscles, impaired counterregulation while sleeping, glucose-lowering medication, and increased insulin sensitivity (2). On the other end of the spectrum, exercise before breakfast may be better for those prone to hypoglycemia or who are taking a glucose-lowering medication because secretion of cortisol, a hormone that increases insulin resistance, usually is highest in the morning. Running after a meal may best suit the needs of a person trying to either manage weight or limit overall carbohydrate count. If a person is unable to run after a meal, the RDN is to encourage and support the client in choosing any time during the day for exercise (4).

**Duration**

A runner’s greatest enemy is fatigue, often caused when glycogen has been depleted, which usually occurs with moderately paced exercise lasting longer than 90 minutes. Most 5Ks or 10Ks are completed within 90 minutes, but if periods of higher intensity occur during the race, depletion can occur earlier due to the more rapid uptake of glucose and impairment of fuel from fat stores (4).

**Macronutrient Usage During Varying Intensities**

Different exercise intensities draw on different macronutrient sources for energy. Low-intensity running uses a mixture of carbohydrates, fats, and some amino acids. Moderate-intensity running can use a mix of fats from adipocytes as well as carbohydrates (6). As the run becomes more intense, the body relies increasingly on carbohydrates for energy. Intense running, as may be seen during the sprint at the end of the race (greater than 80% maximum oxygen consumption), uses 100% carbohydrates, primarily from muscle glycogen. Without supplemental carbohydrates, the individual must tap into glycogen stores for energy. If the activity continues without supplemental carbohydrates, glycogen stores become depleted, potentially resulting in hypoglycemia, especially for those taking a glucose-lowering medication.

**Hormonal Changes**

Key hormonal changes also occur during exercise. Running at a lower or moderate intensity can trigger a “feed-forward” signal to keep the body in euglycemia, whereas high-intensity running triggers a “feedback” response that involves release of catecholamines that can increase blood glucose. During high-intensity exercise, there is a 14- to 18-fold increase in epinephrine and norepinephrine compared with a two- to fourfold increase that occurs with moderate-intensity exercise (6). This increase in blood glucose can lead to hyperglycemia because glucose production is greater than glucose utilization. Activities of a shorter intensity and those that last fewer than 50 minutes are not likely to require carbohydrate ingestion because of the greater release of glucose-raising hormones such as adrenaline (6).

**Training Adaptations**

As people adapt to their training regimens, their ability to metabolize fat increases. The ability to use fat for energy slows depletion of muscle glycogen, reduces reliance on blood glucose, and ultimately decreases the amount of carbohydrates needed during the run. In addition, release of the glucose-raising hormones (epinephrine and norepinephrine) is reduced during moderate- to low-intensity exercise, resulting in decreased release of glucose (2)(4).

**Fueling Needs Before and After the Run**

After addressing the previously mentioned general exercise factors, the RDN assesses fueling needs and appropriate adjustments during training. Carbohydrates provide the needed energy during exercise and adequate fuel for endurance and glycogen recovery. The person with T2D must maintain a delicate balance of keeping glucose levels within a normal range while providing necessary energy for running (7).

Carbohydrate counting allows the runner with T2D flexibility for changing circumstances, such as a delay in the starting time for a race or adjusted time of a training run (8). The carbohydrate count takes into consideration baseline energy needs, training schedule (including changes in the training plan), and pre- and postevent carbohydrate needs calculated by body weight.

Timing of fueling determines whether a higher- or lower-glycemic index (GI) carbohydrate should be consumed for fueling. A runner may need to consume higher-GI carbohydrates closer to exercise time for a faster release of glucose and to minimize gastrointestinal distress such as bloating, a feeling of fullness, or diarrhea. Generally, a good rule of thumb is 1 g/kg/hour up to 4 hours before exercise (9). Throughout the rest of the day, the general recommendation of consuming low- to moderate-GI carbohydrates is appropriate (10).
**Nutrition During the Run**

Consuming carbohydrates during the run can delay fatigue, improve endurance, maintain blood glucose levels, and prevent hypoglycemia. The decision to replace carbohydrates depends on the duration and intensity of the run and whether the runner with T2D is prone to hypoglycemia (2).

**Post-run Nutrition**

Nutrition after the run is important to optimize recovery, promote desired adaptations to a training regimen, and stabilize blood glucose. As soon as 30 to 60 minutes after a run, muscles take up blood glucose at a faster-than-normal rate to replace expended muscle glycogen. This rapid uptake of glucose, in conjunction with insulin release, can create delayed hypoglycemia, which can occur up to 48 hours after exercise. Preventing delayed hypoglycemia requires a plan for consistent and adequate carbohydrate consumption before, during, and after exercise (10).

If the runner is concerned about carbohydrate consumption or watching caloric intake, adding a small amount of protein (0.3 g/kg/hour) to suboptimal carbohydrate intake (<1 g/kg/hour) can aid in muscle glycogen restoration. This may be a better strategy for those with T2D because maintaining energy stores on the lower side may maximize glucose for glycogen stores rather than blood glucose.

Consuming 15 to 25 g protein can repair, refuel, and aid in net muscle-protein balance. This amount of protein also can promote muscle-tissue repair and enhance adaptations such as new protein synthesis and increased glycogen storage (10). Insulin users likely need a higher amount of protein and fat after exercise and as a bedtime snack to prevent hypoglycemia (4).

**Summary**

RDNs can counsel their clients with diabetes who are runners about appropriate nutrition interventions during exercise and the factors that require ongoing monitoring throughout the course of the runner’s training. Educating our patients with type 2 diabetes on training adaptations and key action steps to maintain glucose stability will help them to successfully continue their running activities.

**References**

Abstract
Individuals who participate in extreme ultra-endurance exercise, such as Ironman triathlons, running or cycling more than 100 miles in a single event, or even mountaineering, continually push the limits. Both training and competition for these events require proper replacement of carbohydrates and fluids to maintain performance. Individuals with type 1 diabetes (T1D) have the added challenge of monitoring and maintaining proper glycemia. The diagnosis of T1D should not be perceived as a limitation for any person. With proper planning and knowledge of the interaction of diet, exercise, and training, athletes with T1D can be successful at any level of competition.

Introduction
T1D is an autoimmune disease characterized by progressive B-cell destruction that inevitably leads to dependence on exogenous insulin for survival and proper metabolic function (1). Before the discovery of insulin in 1920, individuals diagnosed with T1D were discouraged from taking part in any physical activity due to the high medical risks associated with this metabolic condition (2). Today, individuals with T1D are encouraged to embark on physical activity because such activity has been shown to contribute to physical fitness, better weight management, enhanced insulin sensitivity, and improvement in postprandial glycemia (1).

With all the advancements in diabetes medications and monitoring technology, the barriers that once held individuals with T1D back from safe exercise are breaking down (3). Athletes with T1D push their limits in every level of sport, ranging from recreational to the Olympic level. Some athletes even participate in extreme ultra-endurance exercise. This type of exercise primarily consists of cycling, running, swimming, or skiing for more than 4 consecutive hours (4). Success in these events, however, requires meticulous planning and preparation. Throughout training, athletes with T1D must pay close attention to the many variables affecting their blood glucose and adjust them appropriately to optimize performance.

Exercise Metabolism in T1D in Endurance Sport
Of the many considerations for athletes with T1D entering a training session or event, insulin dosing and carbohydrate (CHO) replacement are among the most important. Consistent, successful manipulation of these variables can enable the athlete to perform optimally without experiencing either hypo- or hyperglycemia (5). Due to the great variability among athletes, no effective guidelines exist for the adjustment of these two variables (6). In short, the athlete with T1D must learn to manipulate insulin dosing and CHO replacement through trial-and-correction to best match both glucose appearance into the blood and glucose disposal through oxidation (6).

Because glucose uptake may increase up to 20-fold during exercise, the athlete must modify insulin and CHO to best match the rate of use by the active skeletal muscle (3). Improper adjustment may lead to substantial fluctuation in blood glucose concentrations, resulting in either hyper- or hypoglycemia. Many athletes involved in endurance-based exercise struggle to prevent hypoglycemia, and without proper guidance their participation and performance may be detrimental (7). This article focuses on glycemic management for athletes with T1D involved in events lasting more than 4 consecutive hours.

In individuals without diabetes, euglycemia throughout exercise is maintained via a balance in circulating concentrations of hormones (insulin, glucagon, growth hormone, cortisol), the metabolic demands of the activity (predominantly duration and intensity), hydration, and ingested
CHOs (1). Previous research has revealed a direct correlation between duration of exercise and frequency of hypoglycemia in endurance athletes with T1D (7). The inability to decrease circulating insulin intrinsically at the onset of exercise is a major contributor to this occurrence, often leading to relative hyperinsulinemia and hypoglycemia (8). Another important consideration is the loss of glucagon release in response to hypoglycemia, which is commonly seen in those who have had T1D for greater than 5 years (9). Loss of this glucose-raising response may increase the athlete’s susceptibility to severe hypoglycemia.

When rapid-acting prandial insulin doses and, in some cases, long-acting basal insulin doses are not properly adjusted before starting activity, the resulting hyperinsulinemic state may lead to decreased mobilization and oxidation of fatty acids as well as attenuation of hepatic glycogenolysis and gluconeogenesis (10). Because endurance exercise is primarily performed at submaximal intensities, where fatty acids are mobilized and oxidized at a higher rate, the athlete is much more susceptible to hypoglycemia if proper CHO is not consumed (11). The athlete will likely require an elevated CHO intake during the event to maintain proper glycemia.

Hypoglycemia (blood glucose [BG] <70 mg/dL) is a common adverse effect of physical activity in those with T1D (12). As circulating glucose concentrations decrease below 70 mg/dL, a variety of adrenergic and neuroglycopenic symptoms such as dizziness, lightheadedness, palpitations, and sweating may present (3,13).

### Considerations for Athletes with T1D

Planning for training sessions or events is vital for the endurance athlete with T1D. The ability of the athlete to adjust insulin and ingested CHO throughout 4 or more hours of activity is displayed in the glycemic trend throughout the activity. Investigators have observed that performance variables such as peak workload, peak oxygen consumption, and cardiac output are decreased in T1D, but decreases in these variables are not as great in the presence of good overall glycemic management (5). Monitoring via finger-stick or continuous glucose monitor (CGM) is essential to determine exercise glucose trends. However, checking a BG value during a competitive event is not conducive to optimal athletic performance. For example, such monitoring may require the athlete to stop or slow down in a timed event (14). Checking at 30-minute intervals has been proposed for endurance athletes (3).

Use of a CGM throughout the activity may assist the athlete in making informed decisions about increasing or decreasing CHO consumption or administering insulin. Because the threshold for hypoglycemia-related symptoms and intrinsic counterregulatory response decreases with exercise (14–16), simply treating glycemic flux based on feelings or symptoms may not always be successful. Treating based solely on feelings or the presence of usual symptoms may become confounded when dehydration is present, since some symptoms occur in both conditions (17).

### Nutrition During and Following Extreme Endurance Exercise

To ensure proper athletic performance and recovery, the athlete with T1D must consume appropriate amounts of dietary CHO to replenish glycogen stores and supply a readily available source of energy during sport (4). Dietary guidelines for athletes with T1D should not differ from those without T1D, although elevated CHO requirements may present a challenge to maintain proper glycemia (18). For the ultra-endurance athlete training more than 4 to 5 hr/day, a daily CHO intake of 6 to 12 g/kg bodyweight has been proposed (Table) (4,18–20). A meal consisting of 1 g/kg bodyweight high-glycemic CHO consumed 1 hour before the event has been proposed to “top off” glycogen stores (18). Due to altered metabolic dynamics in T1D, a 33% decrease in total

### Table. Carbohydrate Guidelines for Endurance Athletes (18)

<table>
<thead>
<tr>
<th>Notes</th>
<th>6-12 g/kg bodyweight</th>
<th>1 g/kg bodyweight</th>
<th>30-90 g/hr</th>
<th>1-1.5 g/hr&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Daily Recommendation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Hour Before Exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Throughout Exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediately Following Cessation of Exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> Within 30 minutes

<sup>2</sup> Repeat every 2 hours for 4-6 hours post exercise
glycogen is seen in endurance athletes when compared to controls (16), but with proper timing of CHO ingestion, this difference may dissipate. As exercise progresses and the duration increases, athletes must ingest CHO by means of sugary liquid, gels, or solid food to maintain BG concentrations and prevent dehydration (3,4,18,21). CHO recommendations during exercise range from 30 to 90 g/hr, but this intake must be tailored to the individual and his or her training intensity (4,19,20). Along with this CHO intake, endurance athletes are also encouraged to replace fluids at a rate of 600 to 1,200 mL/hr (17). Through training and monitoring of intake, the athlete should develop an individualized strategy that evolves as fitness level and training plan change. Improper consumption of CHO and fluids throughout exercise not only can result in undesired glucose flux but may cause gastrointestinal distress (20).

Upon completion of an endurance event or training session, glycogen stores must be replenished to ensure proper performance as well as prevent late-onset hypoglycemia. Late-onset hypoglycemia may present up to 24 hours after activity (10,19). Close monitoring of glucose becomes especially important when considering the increased rate of nocturnal hypoglycemia seen in athletes (22). The inability to respond appropriately during this period may present a danger for the athlete.

Following glycogen-depleting exercise, the sarcolemmal permeability of glucose is significantly increased through increased activity of glycogen synthase (7). In this first stage of glycogen replenishment, minimal to no insulin is required. Once glycogen levels are near normal, the need for insulin is increased and the rate of replenishment is slowed (7). Recommendations relating to rapid replenishment of glycogen call for 1.0 to 1.5 g/kg bodyweight of carbohydrate within the first 30 minutes of stopping the activity, repeated every 2 hours for up to 4 to 6 hours (20). The athlete may need to adjust insulin dosing to ensure proper uptake of CHO while maintaining blood glucose values within range.

**Glycemic Management During and Following Exercise**

Adjustment of insulin for increased CHO intake is a skill best learned through good monitoring throughout training (3). A pre-exercise BG value between 100 and 250 mg/dL is accepted as safe for beginning exercise, with most athletes aiming for a range of 120 to 180 mg/dL (3). Entering exercise with BG values within this range prevents the shift toward increased CHO oxidation during exercise that is seen in hyperglycemia (19). Athletes with T1D must also monitor for ketones before exercise when a BG greater than 250 mg/dL is present. If insulin is reduced too aggressively, hypoinsulinemia may occur (3) and exercise may not be safe due to ketone formation (1). On the other hand, hypoglycemia within the 48 hours before exercise is linked to an attenuated counter regulatory response (up to 50%), elevating the athlete's risk of subsequent hypoglycemia due to a decreased effect of counterregulatory hormones (10,23).

Hyperglycemia-induced osmotic diuresis is also of great concern when BG exceeds 180 mg/dL because that concentration may lead to increased urination, fluid loss, and dehydration (13). With as little as a 2% decrease in total body water, cognitive function and physical work capacity are impaired (4). To prevent this occurrence, athletes with T1D should drink liquids without glucose until BG values have normalized throughout the activity (13). When BG is within range (120-180 mg/dL), beverages containing at least 8% CHO are recommended (18) in volumes mentioned earlier.

**Insulin Considerations with Exercise**

As stated previously, the inability to decrease circulating levels of insulin, as seen in individuals without T1D, necessitates increased planning before exercise (24). Prevention of hypoglycemia throughout endurance exercise requires insulin adjustments by decreasing either prandial or basal insulin (18,24). For individuals using a pump for insulin infusion, more on-the-go changes may be made in their insulin dosing, which may be beneficial (25). When calculating the magnitude of dose reduction for extreme activity, a few additional variables must be considered, including timing of dose (26), stress (19), altitude (27), and environmental temperature (10,13).

When exercise is performed within 2 hours of a scheduled prandial dose of rapid-acting insulin, a reduction may be required. If no reduction is made, a CHO intake exceeding the recommendations may be necessary to maintain glycemia (26). According to West and associates (24), a 75% insulin dose reduction simultaneous with a low-glycemic index snack within 30 minutes was effective in preventing exercise-induced hypoglycemia. Lower-glycemic index snacks are preferable at this time because they increase BG much more

27
slowly (28). When pre-exercise glucose values near hypoglycemia (<70 mg/dl), a higher-glycemic index snack may be preferred to raise BG quickly and prevent hypoglycemia. Campbell and colleagues (22) showed a 50% insulin dose reduction before and after exercise was effective in preserving glycemia.

The stress and anxiety that sometimes accompany competition must also be considered (19). Elevated stress levels before activity may contribute to a heightened counterregulatory response through increased circulating hormones such as cortisol and epinephrine. Increased circulating concentrations of these hormones stimulate glucose production and may contribute to hyperglycemia (25).

When exposed to very high or low temperatures, the expected mechanics of insulin and the accuracy of glucose meters may become altered (10,13). Substantial deviations in temperature may alter both the absorption of insulin from its subcutaneous depot and the integrity of the insulin itself. For example, blood flow to the skin may be decreased in cold conditions, resulting in a slower appearance of circulating insulin (13). The inverse is true for very warm conditions. For individuals receiving insulin through an insulin pump, protecting the insulin within the device is of great importance. These variables decrease the already low reproducibility of insulin injection mechanics (10).

Athletes must pay greater attention to the glucose meter when participating in sports at high altitudes, such as mountaineering or skiing. When exposed to elevations of greater than 2,700 m (8,858 ft), glucose meters tend to underestimate the current BG substantially (27). Athletes competing at such altitudes in frigid temperatures might consider use of a CGM throughout exercise to potentially decrease the number of finger sticks required to monitor blood glucose levels. If properly calibrated and protected, both the CGM and glucose meter may provide more accurate information than if it was to be exposed. The athlete may consider storing their supplies in a pouch close to bare skin if possible. The glucose meter plays a vital role in ensuring the safety of the athlete. For this reason, proper thermoregulation of all diabetes supplies must be emphasized for both hot and frigid conditions.

**Conclusion**

Athletes across the globe with T1D are competing in endurance exercise. Aside from proper training, success lies in how well these athletes can match the energy demands of exercise with proper insulin dosing and CHO replacement. The development of CGMs and the creation of rapid-acting insulins has enabled more accessible monitoring throughout exercise, but such technology is affected by environmental factors, and must be protected. Because of the substantial individual variation among athletes, daily CHO intake, insulin dosing, and CHO intake throughout exercise must be adjusted on a case-by-case basis, with emphasis toward the athlete’s preference and safety.

**References**


Hypoglycemia Prevention Among Active Youth with Type 1 Diabetes

Rachel Head, RD, CDE
Diabetes Program Manager
Phoenix Children’s Hospital Diabetes Program
Phoenix, AZ

Abstract
Children with type 1 diabetes (T1D) are at increased risk for hypoglycemia during and after physical activity. Despite the well-documented health benefits of physical activity in T1D, hypoglycemia and fear of hypoglycemia continue to pose barriers for families of active youths. Education on strategies to prevent and, if needed, treat exercise-related hypoglycemia can support families as they establish and maintain healthy activity habits.

Introduction
Children with T1D run the gamut from playful toddler to teenage athlete. Because children engage in activity differently from their adult counterparts, many general recommendations require modifications to meet their needs. Families and health care teams must work closely to tailor therapy for these children that encourages participation and continuation of physical activity for its multiple health benefits (1).

Literature Review
United States Department of Health and Human Services Guidelines advise that children spend at least 60 min/day in moderate-to-vigorous intensity physical activity (2). Several barriers to activity have been cited among people with T1D, with the primary deterrent being an increased risk for hypoglycemia (3), including delayed-onset hypoglycemia (4). The risk of exercise-induced hypoglycemia in T1D stems from increased insulin sensitivity, increased uptake of glucose by skeletal muscle, and the absence of normal counterregulatory hormone responses (5)(6). Research demonstrates that the glucose-lowering effects of activity can persist long after returning to a resting state, with increased glucose needs during activity, immediately after activity, and 7 to 11 hours after the activity in the course of the glycogen repletion process (7). Coupled with the often unpredictable nature of childhood, exercise-related hypoglycemia remains a challenge for caregivers to anticipate, prevent, and treat.

Postponing activity is recommended in the presence of pre-exercise blood glucose values of less than 100 mg/dL, hyperglycemia with moderate-to-large ketones, or any prohibitive symptoms of hypo- or hyperglycemia (8). The pre-exercise blood glucose recommendations may need to be further adjusted for very young children or children with greater insulin sensitivities because baseline glucose values are a strong predictor of hypoglycemia risk (9). Even when asymptomatic pre-exercise blood glucose values are comfortably within the child’s recommended range, many challenges remain to maintaining glycemic control during and after physical activity.

Clinical Application: Prevention of Hypoglycemia
Following is a summary of recommendations for hypoglycemia prevention among active youth with T1D. Patient experiences should guide further individualization of these recommendations. Monitoring of pre- and postexercise glucose concentrations can help to establish a pattern for insulin and carbohydrate adjustments for the child’s preferred activities, thereby limiting unintended hyperglycemia and excess energy.

Before Planned Activity Within 1 to 2 Hours After Meals
If the intensity and duration of the activity are known, caregivers can consider a predetermined

<table>
<thead>
<tr>
<th>Table 1. Adjustment of Preprandial (Rapid-acting) Insulin Dose According to Intensity and Duration of Physical Activity (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exercise Intensity (%VO_{2max})</strong></td>
</tr>
<tr>
<td>Mild ~25</td>
</tr>
<tr>
<td>Moderate ~50</td>
</tr>
<tr>
<td>Heavy ~75</td>
</tr>
</tbody>
</table>

%VO_{2max} = percentage of maximal oxygen consumption
percentage by which the rapid-acting insulin can be decreased (10). The addition of protein in a meal or snack preceding activity may also help avoid hypoglycemia (11).

**Before Planned Activity, Before or Between Meals and Unplanned Activity**

Planned activity generally requires straightforward glycemic management strategies, but many typical childhood activities are unplanned and intermittent. Providing uncovered carbohydrate before exercise is an effective strategy to prevent hypoglycemia for such spontaneous activities and activities when planned bolus adjustments are not an option (such as before meals and more than 2 hours after meals) (11). The amount of carbohydrate needed varies, depending on exercise intensity and active insulin. Some moderate (50%-75% percentage of maximal oxygen consumption [VO2max]) to vigorous (>75% VO2max) activities may require up to 1 to 1.5 g/kg bodyweight of carbohydrate per hour when pre-exercise insulin doses are not decreased and insulin is at its peak action (12). Smaller carbohydrate amounts are indicated for activities that take place when rapid-acting insulin concentrations are low. In these cases, caregivers can use 0.3 to 0.5 g/kg of carbohydrate per hour as a starting point.

Optimal carbohydrate sources include rapidly absorbed isotonic fluids containing 5% to 10% carbohydrate solution, including sports drinks or diluted juices (12) (13), as well as high-glycemic index foods such as crackers or cereal. Glucose tabs and gels can be used if tolerated by the child. High-fat foods that delay glucose absorption should be avoided for treatment of hypoglycemia during exercise (14).

**Postexercise**

Additional precautions may be needed to ward off hypoglycemia after activity. For older children, short-duration, high-intensity movement (such as sprints) performed after aerobic activity has been shown to reduce the risk of hypoglycemia up to 2 hours after exercise due to increased counterregulatory hormones and resulting glycogenolysis (15)(16). Caregivers can provide a high-carbohydrate meal within 30 to 120 minutes of prolonged and intense aerobic activity to expedite glycogen repletion in the skeletal muscles, thereby blunting a postexercise decrease in blood glucose (14). The addition of protein and fat, such as in whole milk, has been shown to help stabilize postexercise blood glucose concentrations (17). Further insulin adjustments may be warranted based on individual experience, including reductions in the subsequent mealtime bolus, overnight basal, and/or next-day basal insulin doses.

**Basal Adjustments**

Certain basal adjustments can be considered for patients on insulin pump therapy. Although basal insulin reductions can avert hypoglycemia during and after activity, they have inherent limitations as an immediate prevention strategy due to their action time and potential to contribute to unintended hyperglycemia (18). For planned activities, temporary basal decreases can be helpful for reducing circulating concentrations of insulin when the duration is anticipated to be more than 2 hours or when reductions are set 60 to 90 minutes in advance of the activity. Disconnection from the insulin infusion site should be limited to 2 hours to avoid rebound hyperglycemia and ketone production and should be accompanied by frequent blood glucose checks (18).

Temporary basal decreases are perhaps most useful in the prevention of delayed-onset hypoglycemia, with one study demonstrating reduced risk during a 20% basal reduction overnight after moderate-to-vigorous intensity physical activity that occurred in the late afternoon and evening (19). A bedtime and/or overnight blood glucose check can be useful for evaluating an appropriate percentage for future basal reductions.

**The Role of Technology**

Diabetes technology provides more options for managing glucose concentrations during activity, potentially creating a stronger safety net for active children (20). Insulin pumps easily allow for bolus and basal adjustments as well as insight into circulating insulin concentrations via the insulin-on-board feature. The most recent technology trend is to equip caregivers and coaches with devices for observing continuous glucose values in real time. Although not all hypoglycemic events may be captured by continuous glucose monitoring in real time due to a lag effect of the interstitial fluid by which the glucose values are measured, one study suggested that aerobic activity may be the exception and may be associated with improved accuracy in continuous glucose monitoring values (21). Monitoring the rate and direction of glucose trends can contribute to a better understanding of the real-time effects of activity and can help caregivers further fine tune insulin and carbohydrate adjustments for exercise. During follow-up visits, clinicians should assess tubing and site issues (e.g., adhesive failure due
to perspiration), thereby ensuring that the technologies remain feasible during periods of heightened glycemic variability.

Clinical Application: Self-Management Education
A variety of hypoglycemia self-management education topics are appropriate for caregivers and specific school or sports personnel (Table 2).

Summary
Although many variables affect children with T1D, physical activity can be managed safely when caregivers and health care teams collaborate and individualize therapy. Encouraging the continuation of normal activities is of utmost importance and can contribute to healthy habits long into adulthood. Education on the prevention of exercise-related hypoglycemia will ensure that families, caregivers, and school personnel can help the child with T1D engage in planned and unplanned activities with confidence.

Table 2. Self-management Education Topics for Caregivers

| Healthy Eating                          | • Consuming consistent pre-exercise mealtime nutrient composition when possible  
|                                        | • Consuming consistent carbohydrate treatment for lows when possible  
| Being Active                           | • Identifying levels of intensity using a rating of perceived exertion scale or talk test  
|                                        | • Reviewing effects of short-duration, high-intensity activities and mixed-intensity activities  
| Monitoring                             | • Establishing individualized pre-exercise blood glucose target ranges  
|                                        | • Monitoring blood glucose before and after activity, including logging/journaling, and interpretation of the results (including continuous glucose monitoring reports if applicable)  
|                                        | • Monitoring blood glucose every hour during activity for strenuous and/or prolonged activities and for unfamiliar activities  
| Taking Medications                     | • Understanding onset, peak, and duration of each insulin type and interpreting insulin-on-board  
|                                        | • Reviewing use of rescue medications such as glucose tablets, glucose gels, and glucagon  
| Problem-solving                        | • Identifying the effects of dehydration, altitude, humidity, and other factors on blood glucose values  
| Reducing Risks                         | • Identifying signs and symptoms of hypoglycemia, particularly if the child is unable to verbalize them  
|                                        | • Preventing hypoglycemia during and after activity, including delayed-onset hypoglycemia strategies and more aggressive methods if antecedent hypoglycemic episodes have occurred (22)  
|                                        | • Reviewing appropriate treatment of acute hypoglycemia, should it still occur despite precautions  
|                                        | • Advance planning of “ready access” to easily absorbable carbohydrates, testing supplies, and glucagon  

References


Introduction
Sorting through the hundreds of fitness apps, wearable technology devices, and online trackers can be overwhelming for educators, much less their patients with diabetes. With so many choices, how do you help patients know which is best for them? In reality, there is no single best fitness tool; the most appropriate tool depends on the patient’s needs, preferences, and personality and what he or she wants to track.

Benefits of Fitness Tools
There are many benefits to fitness tools (1,2). They can:
• Provide greater insight on blood glucose trends, weight, and fitness levels, which can help spark behavior change.
• Offer motivation and support between clinical visits. The information gleaned from the tools can be used by the clinician or Certified Diabetes Educator and the patient to set behavior change goals.
• Encourage activity by providing tangible support.
• Help in understanding the concept of mindfulness.

Apps
Table 1 lists samplings of fitness apps that have useful fitness features.

Because the basic versions of the apps listed are free and versions are always changing, why not try them before recommending to patients? Also, be sure to have your patients check with their health care provider to make sure the specific activity is safe for them.

General online support systems for fitness and weight management also are available (Table 2).

Wearable Fitness Trackers
A wide range of fitness trackers are available as wristbands or clip-ons. Finding the right one for a patient requires obtaining specific information about the features he or she wants and needs. Features include:
• GPS systems.
• Heart rate monitors.
• Three-axis accelerometer to monitor movement and sleep habits.
• Allow inputting health data, including calorie intake, stress level, weight, and blood glucose readings.
• Ability to synch with a wireless body weight scale.

By no means comprehensive, Table 3 provides samples of various wearable devices.

Making Fitness Tools Work
No matter how sophisticated the tool, it only works if a person uses it. The following are some tips for encouraging patients to begin their fitness quest (2):
• Is your patient concerned about no time to log? Investigate what the patient is doing. How much time is he or she spending watching TV, surfing the web, or checking Facebook?
• Perhaps some patients are not ready to track fitness. Suggest they start by simply taking pictures of themselves when they exercise.
• Send your patient a reminder with a link to an app or tracking system.
• Ask your patient to share successes and challenges weekly, and you provide immediate feedback, even if it’s just a quick note regarding his or her progress.
• Encourage your patient to try a new fitness tool for 2 to 4 weeks. If one tool does not work, suggest trying another one.
• Track yourself! If fitness tracking is something you wouldn’t do yourself, you really cannot ask your patients to do so.
### Table 1. Fitness Apps Summary

<table>
<thead>
<tr>
<th>App Name</th>
<th>Description</th>
<th>Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose Buddy (SkyHealth LLC): <a href="http://www.glucosebuddy.com/">http://www.glucosebuddy.com/</a></td>
<td>Users can enter blood glucose numbers, carbohydrate intake, insulin dosage, and activities and link online for complete functionality. iOS and Android.</td>
<td></td>
</tr>
<tr>
<td>MyFitnessPal (MyFitnessPal, Inc): <a href="https://www.myfitnesspal.com/">https://www.myfitnesspal.com/</a></td>
<td>Tracks food intake (including calories and macronutrients) and physical activity. Community support adds a social element for support and motivation. iOS and Android.</td>
<td></td>
</tr>
<tr>
<td>Diabetes Kit (Diabetes Labs): <a href="http://diabeteskitapp.com/">http://diabeteskitapp.com/</a></td>
<td>Sends personalized, actionable insights created by a Certified Diabetes Educator to the app based on the user's daily activities. iOS.</td>
<td></td>
</tr>
<tr>
<td>Endomondo: <a href="https://www.endomondo.com/download">https://www.endomondo.com/download</a></td>
<td>A social fitness network that allows users to track runs, bike rides, and other outdoor activities. It also has training plans and coaching features available with an upgrade. iOS and Android.</td>
<td></td>
</tr>
<tr>
<td>Nudge Health Tracking (Nudge, LLC): <a href="https://www.nudgeyourself.com/">https://www.nudgeyourself.com/</a></td>
<td>Works like a dashboard, integrating more than 80 fitness and nutrition apps into one number that it calls the “Nudge Factor” to rate overall health and wellness. Also provides tips on how to improve the score. iOS and Android.</td>
<td></td>
</tr>
<tr>
<td>The 7 Minute Workout (Variety available): <a href="http://www.uovo.dk/the-7-minute-workout/">http://www.uovo.dk/the-7-minute-workout/</a> <a href="https://7minuteworkout.jnj.com/">https://7minuteworkout.jnj.com/</a></td>
<td>A high-intensity circuit training workout with 12 exercises using the individual’s own body weight, a chair, and a wall. iOS and Android.</td>
<td></td>
</tr>
<tr>
<td>MapMyWayWalk (MapMyFitness, Inc): <a href="http://www.mapmywalk.com/">http://www.mapmywalk.com/</a></td>
<td>A great app to use while traveling that offers 70 million walking routes. iOS and Android.</td>
<td></td>
</tr>
<tr>
<td>Pedometer++ (David Smith &amp; Cross Forward Consulting, LLC): <a href="http://pedometerplusplus.com/">http://pedometerplusplus.com/</a></td>
<td>The app icon matches with the number of steps a person takes so that users do not have to open the app to see their steps. iOS.</td>
<td></td>
</tr>
<tr>
<td>Sworkit Lite (WORKIT by Nexercise Apps, Inc): <a href="http://sworkit.com/">http://sworkit.com/</a></td>
<td>Offers strength, yoga, Pilates, and stretching workouts from 5 to 60 minutes in length. iOS and Android.</td>
<td></td>
</tr>
<tr>
<td>AADE Diabetes Goal Tracker <a href="https://www.diabeteseducator.org/patient-resources/diabetes-goal-tracker-app">https://www.diabeteseducator.org/patient-resources/diabetes-goal-tracker-app</a></td>
<td>Set personal goals in the AADE7 Self-Care Behaviors and track progress with these goals as well as share goals and progress with others. iOS and Android.</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2. Online Support Systems Summary

<table>
<thead>
<tr>
<th>Website</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://www.sparkpeople.com">www.sparkpeople.com</a></td>
<td>Free online community for tracking calories and exercise with a strong social support network as well as educational and motivational articles and videos from health professionals, including a registered dietitian nutritionist. The variety of apps for both iPhone and Android include tracking, inspirational quotes, and recipes.</td>
</tr>
<tr>
<td><a href="http://www.loseit.com">www.loseit.com</a></td>
<td>Available on Android, iOS, Nook, Kindle, and the Web with a free app to track weight loss, exercise, macronutrient intake, and sleep. In addition, Lose It! integrates with several fitness trackers and digital scales.</td>
</tr>
<tr>
<td><a href="http://www.fatsecret.com">www.fatsecret.com</a></td>
<td>Free apps for iOS and Android to track weight and exercise. Includes recipes plus social networking via their groups, forums, and Facebook.</td>
</tr>
</tbody>
</table>
Both you and your patients may be overwhelmed by the myriad functions of many apps. Look for apps that (1,2):

- Provide feedback
- Use colorful graphs and charts
- Are low-cost or free
- Are easy to use
- Assist in meeting your patient’s personal and diabetes goals
- Communicate data wirelessly to health care provider
- Have the ability to update food counts in database

### Clinical Application

Although fitness tracking tools do not replace clinical advice, they can be useful for helping patients stay motivated with their fitness programs, and experience the many other benefits these tools offer for patients with diabetes.

For example, Susan, a person with T2D, found using MyFitnessPal a simple, easy and effective way to pay closer attention to calorie and carbohydrate intake. The convenience of entering data on her phone allowed her to follow through with consistent tracking. This helped her stay on track between face-to-face visits with her health care provider and educator.

She lost 5% of her body weight, HbA1c levels decreased and she feels more confident about making healthy food choices.

### Table 3. Wearable Fitness Trackers

<table>
<thead>
<tr>
<th>Device</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fitbit (Fitbit Inc):</strong> <a href="https://www.fitbit.com/">https://www.fitbit.com/</a></td>
<td>A variety of products offer a range of services from tracking daily steps and distance to a smart watch that includes a clock, sleep tracking, caller ID, continuous heart rate monitoring, and GPS tracking.</td>
</tr>
<tr>
<td><strong>Jawbone (Jawbone):</strong> <a href="https://jawbone.com/">https://jawbone.com/</a></td>
<td>All products track steps, calories burned, and sleep plus incorporate tracking food intake and goal setting. The more expensive products include Idle Alert, which allows the user to set vibration alarms as a reminder to get up and move regularly, resting heart rate, and an alarm designed to wake the user at the optimum point in the sleep cycle.</td>
</tr>
<tr>
<td><strong>Misfit (Misfit Flash and Misfit Shine) (Misfit, Inc):</strong> <a href="http://misfit.com/?locale=en">http://misfit.com/?locale=en</a></td>
<td>The tracking device can be worn in a variety of locations, including wristband, necklace, or clipped onto a waistband or inside a pocket. Tracks steps, distance, and sleep.</td>
</tr>
<tr>
<td><strong>Striiv Fusion (Striiv):</strong> <a href="http://www.striiv.com/pages/striiv-fusion">http://www.striiv.com/pages/striiv-fusion</a></td>
<td>Combined fitness and smart watch that is water-resistant and tracks activity and sleep.</td>
</tr>
</tbody>
</table>

### Summary

When helping patients choose a fitness tool, make sure it fits their needs. In addition, encourage your patient to read reviews of several different apps and understand the pros and cons of each so they choose the one that is the best fit for them. Cost, safety, and personal goals all play a part in choosing the best fitness tool to help improve the health of people living with diabetes.

### References


Lesson Plans
Developed by Marla Solomon, RD, LD/N, CDE

Health Consequences of Inactivity and Applicable Approaches to Overcome Sedentary Behaviors

<table>
<thead>
<tr>
<th>Instructor’s Plans</th>
<th>Objectives</th>
<th>Student’s Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide an assortment of materials (e.g., handouts, brochures) from various health organizations for students to review and assess for their patients’ health needs.</td>
<td>After review of the organizational materials, the student will recite specific consumer physical activity recommendations that have an impact on chronic diseases and prevention.</td>
<td>The student will design a patient handout with bullet point recommendations to serve as an exercise prescription referral to be signed by a primary care physician or endocrinologist.</td>
</tr>
<tr>
<td>Locate an exercise physiologist, physical therapist, or certified personal trainer to lecture on basic physical activity and the components of an exercise prescription.</td>
<td>After the presentation, the student will identify the various components of an exercise prescription, including its fitness intensity.</td>
<td>The student will design an exercise logbook that includes a patient’s personal exercise fitness intensity rate prescribed by the exercise specialist.</td>
</tr>
<tr>
<td>During the classroom period, lead a discussion with students on their personal involvement with different types of exercise that also addresses students’ and patients’ barriers to exercise.</td>
<td>The student will share his or her own exercise experience with the class and state an exercise goal to be accomplished within 1 week.</td>
<td>Each student will develop a 1-day exercise plan designed to avoid sitting/sedentary actions for more than 90 minutes and to include at least a 10-minute exercise break throughout the day.</td>
</tr>
</tbody>
</table>

Exercise with Diabetes and Physical Limitation

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Present the physiologic processes of the following conditions associated with diabetes: lower vascular disease, peripheral artery disease, osteoporosis, and balance concerns.</td>
<td>The student will review the stages for development of one condition and potential exercise barriers.</td>
<td>In groups of two to three students, each student will research one diabetes complication (3 references) and identify any nutrition connections. Each group will share its findings in a 20- to 30-minute oral presentation.</td>
</tr>
<tr>
<td>Invite a physical therapist with diabetes experience to present diabetes case scenarios of people living with physical limitations.</td>
<td>The student will recite specific reasons for an exercise specialist referral (physical therapy, occupational therapy, sports medicine).</td>
<td>With the expert present, the class will design an exercise handout that includes the following limitations: vascular disease, peripheral artery disease, osteoporosis, and balance concerns.</td>
</tr>
</tbody>
</table>
Supporting Early Adoption of Exercise in Adults With Type 2 Diabetes: What the Nutrition Professional Needs to Know

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Recruit a psychologist to present a classroom lesson on the transtheoretical model and other behavioral change theories.</td>
<td>After the guest presentation, the student will identify concrete methods to assess his or her patient’s level of motivation.</td>
<td>The student will provide a list of physical activity choices to promote self-management.</td>
</tr>
<tr>
<td>Address how each of the following relates to weight reduction/maintenance: the intensity of an exercise prescription, caloric requirements, exercise choices, and glycemic control.</td>
<td>The student will provide a list of physical exercise choices to help avoid noncompliance issues.</td>
<td>The student will develop an exercise patient handout with low- to high-intensity activities that includes the definitions of aerobic and resistance exercises.</td>
</tr>
<tr>
<td>Invite an academic researcher or a professional from the American Diabetes Association to report findings on exercise and diabetes/prediabetes.</td>
<td>The student will learn about current exercise research and share his or her knowledge with patients.</td>
<td>During an instructor-moderated class discussion, each student will present the following information about one to two article references: author, title, year, and primary theme.</td>
</tr>
</tbody>
</table>

Instructor's Plans

<table>
<thead>
<tr>
<th>Instructor's Plans</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Provide an exercise presentation that addresses energy usage of liver glycogen, glucose, and other fuel sources.</td>
<td>After the instructor’s presentation, the student will demonstrate the glucose pathway(s) from energy production needed during a running period.</td>
<td>Each student develops a pathophysiology board to demonstrate the exercise energy process, including hormones.</td>
</tr>
<tr>
<td>Review macronutrient needs during high-intensity exercise and discuss the benefits of exercise for a patient with type 2 diabetes.</td>
<td>The student will recite the macronutrient needs of a patient with diabetes during specific exercise periods.</td>
<td>Using his or her own exercise board developed from the previous assignment, the student will mark on the board macronutrient needs at different stages of exercise intensity.</td>
</tr>
<tr>
<td>Provide an overview of factors that affect glucose control during an exercise period in a person with type 2 diabetes.</td>
<td>After researching a specific exercise factor identified in the article (3-4 references) that influences glucose control, the student will describe its impact on blood glucose for an individual who has type 2 diabetes.</td>
<td>From the five factors identified in the article, the student will research one topic (medications, frequency, time and intensity, hormonal changes, or macronutrients) that has an impact on a person’s ability to achieve exercise goals.</td>
</tr>
</tbody>
</table>

Considerations for the Runner with Type 2 Diabetes

<table>
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<td>From the five factors identified in the article, the student will research one topic (medications, frequency, time and intensity, hormonal changes, or macronutrients) that has an impact on a person’s ability to achieve exercise goals.</td>
</tr>
</tbody>
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### Type 1 Diabetes: Considerations for the Extreme Athlete

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Review the carbohydrate needs of an athlete with type 1 diabetes during a sport event.</td>
<td>After developing a long-distance runner scenario, the student will be able to clearly state the needs for a long-distance runner (intensive exercise) with type 1 diabetes to be successful.</td>
<td>In groups of two students, the student will use the information provided in the article to develop a case scenario that describes a long-distance runner (set height and weight) and his or her preparation for success in a marathon event.</td>
</tr>
<tr>
<td>Invite a technical representative from a continuous glucose monitoring system (CGMS) company to demonstrate the process used during an intensive exercise program for a person with type 1 diabetes.</td>
<td>At the end of the class, each student will demonstrate ability to read the CGMS and blood glucose pattern log of a high-intensity athlete with type 1 diabetes.</td>
<td>Each student will design a meal plan for an athlete with type 1 diabetes at different stages of exercise: before, during and after exercise.</td>
</tr>
</tbody>
</table>

### Hypoglycemia Prevention Among Active Youth with Type 1 Diabetes

<table>
<thead>
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</tr>
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<tbody>
<tr>
<td>Present an overview of hyperglycemia and hypoglycemia in people with diabetes, highlighting possible exercise-related causes and addressing use of basal and bolus insulin.</td>
<td>The student will identify the glucose pathways in physical and nonphysical states with diabetes.</td>
<td>The student will design a sports handout with the following: times to monitor blood glucose with blood glucose goals, impact of exercise on blood glucose, and treatment of low blood glucose during exercise.</td>
</tr>
<tr>
<td>Recruit a representative from a pump or continuous glucose monitoring system (CGMS) manufacturer to discuss the benefits of using diabetes technology when exercising.</td>
<td>The student will demonstrate the ability to interpret a flowsheet from a CGMS or insulin pump.</td>
<td>With the assistance of a certified diabetes educator at a local diabetes center or hospital, the student will follow a patient with diabetes using a CGMS or pump to observe blood glucose patterns while exercising.</td>
</tr>
</tbody>
</table>

### Fitness Tools and Technology: Making a Difference for Your Patients with Diabetes

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>As a class, investigate the different applications addressed in the article.</td>
<td>The student will become proficient in one application and provide feedback by answering questions from peers and demonstrating the process.</td>
<td>During the class discussion, each student will provide a 15-minute presentation about the pros and cons of using the application.</td>
</tr>
</tbody>
</table>
EXECUTIVE COMMITTEE

Chair
Betty Krauss, RDN, CDE
bkmda@aol.com
616-633-5928

Chair-Elect
Susan Yake, RDN, CDE, CLT, CD
yakes36@bigplanet.com

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985-651-2342

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sandymda@aol.com

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lcruss58@gmail.com

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Alyce Thomas, RD
thomasa@sjhmc.org

Policy and Advocate Leader
Carol Brunzell, RDN, LD, CDE
CBRUNZE1@fairview.org

Dietetic Practice Group Delegate
Liz Quintana, EdD, RD, LD, CDE
equintana@hs.cwvu.edu

Nominating Committee Chair
Daisy Seremba, MS, RD, LD, CDE
dseremba@yahoo.com

NEWSLETTER COMMITTEE

NewsFlash Editor
Kathy Warwick, RD, LD, CDE
kathywarwick0@gmail.com

OTCE Editor
Susan Weiner, MS, RDN, CDE, CDN
susan@susanweinernutrition.com

OTCE Associate Editor
Mary Lou Perry, MS, RDN, CDE
mlp4p@virginia.edu

ELECTRONICS COMMITTEE

Web Editor
Jamie Kowatch, MS, RD
jamie@kowatch.net

Assistant Web Editor
Quynh V Tu, DTR
quymemo@gmail.com

Electronic Mailing List (EML) Moderator
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Pamela.tong@gmail.com

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nutriciard@yahoo.com

Webinar Chair
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constancesayer@gmail.com

Diabetes Innovations & Technology Chair
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libbydowns@gmail.com

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Carolyn Harrington, RD, LDN, CDE
carolyn.harrington217@gmail.com

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mccrea85@msn.com

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mtkamonk@comcast.net

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jenoke@comcast.net

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Christin Hebron
psuilunchristin@gmail.com

Membership Retention Chair
Lilly Suazo, RD, LD/N, CDE
lillysuazo@yahoo.com

Social Media Chair
Anna Henry, MPH, RD, CDE
anna.e.henry@gmail.com

DPBPN Liaison
Sandra Parker, RDN, CDE
sandymda@aol.com

ACADEMY/DCE STAFF

Administrative Manager
Linda Flanagan Vahl
312-899-4725 / Fax: 312-899-5354
lflanagan@eatright.org

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www.dce.org
After reading this issue of On The Cutting Edge, “Going The Distance: Exercise Prescriptions For The Beginner, Intermediate and Advanced Person With Diabetes,” current DCE members can earn 4.0 hours of free continuing professional education units (CPEUs level 2) approved by the Commission on Dietetic Registration (CDR). CPE eligibility is based on active DCE membership status from June 1, 2015 to May 31, 2016.

DCE members must complete the post-test of the CPEs page on the DCE website: http://www.dce.org/resources/cpeus by 2/13/18. For each question, select the one best response. After passing the quiz, to view/print your certificate, access your CPEU credit history or view the learning objectives, go to: http://www.dce.org/account/history.

Please record 4.0 hours on your Learning Activities log and retain the certificate of completion in the event you are audited by CDR. The certificate of completion is valid when the CPE questionnaire is successfully completed, submitted, and recorded by DCE/Academy of Nutrition and Dietetics.

CPE Credit Self-Assessment Questionnaire

Select the one best answer for each question below.

1) Many professional organizations, including the American Heart Association, suggest improved health outcomes by limiting the duration of sitting to
a. No more than 8 hours/day
b. No more than 10 hours/day
c. No more than 90-minute intervals
d. No more than 190-minute intervals

2) Exercise guidelines for adults with type 2 diabetes include
a. No more than two consecutive days between exercise sessions
b. Aerobic exercise for 2 hours/day for 3 days/week
c. 15 minutes of high-intensity exercise per session
d. Inclusion of resistance exercises every day

3) Which of the following statements regarding resistance training is true?
a. It causes decreased insulin sensitivity
b. It may result in reduced fasting glucose
c. It has no effect on waist circumference
d. It must be performed with aerobic exercise to be effective

4) An appropriate recommendation for children with type 1 diabetes who participate in vigorous, spontaneous activity where insulin adjustment is not an option is:
a. Ingest 1 to 1.5 g of carbohydrate/kg/hr
b. Inclusion of a snack limited to 15 g carbohydrate, such as a small piece of fruit
c. A high-protein, high-fat snack such as whole milk, immediately before exercising to balance glucose absorption
d. Drinking additional water to insure adequate hydration and avoiding isotonic fluid, such as sports drink

5) Technology-based fitness tools
a. Can provide motivation and support
b. Are designed for everyone, not just people with diabetes.
c. Can be used by the clinician to set behavior change goals
d. All of the above

6) Exercise recommendations for individuals with Charcot foot include
a. Use of thin shoes to allow for ventilation of the skin during walking
b. Walking a minimum of 90 consecutive minutes daily to optimize blood flow to the foot
c. Non-weight-bearing activities such as swimming and resistance training
d. Weight-bearing exercises done in short high-intensity intervals

7) During exercise, persons with diabetes may experience dizziness, lightheadedness, palpitations and sweating
a. As glucose concentrations decrease
b. Only when dehydrated
c. Requiring immediate insulin administration
d. All of the above

8) Recommended nutrition for a person with diabetes after a run includes
a. 15 - 25 g protein to repair tissue
b. Fat to prevent hypoglycemia
c. Carbohydrate to stabilize blood glucose
d. All of the above

9) Insulin provision before exercise is dependent upon
a. Duration of exercise
b. Intensity of exercise
c. Temperature of the environment
d. All of the above

10) Which one of the following recommendations would NOT support early adoption of exercise in individuals with T2D?
a. First, focus on incorporating more activities of daily living
b. Subjective exercise intensity may need to be lower than “somewhat hard”
c. When progressing exercise in early adopters, increase the intensity first and then frequency/duration
d. Encourage exercise that promote an affective response
Continuing Professional Education Certificate of Attendance
-Attendee Copy-

Participant Name: 

RD/RDN/DTR Number: 

Session Title: OTCE- Going the Distance: Exercise Prescriptions for the Beginner, Intermediate and Advanced Person with Diabetes

CDR Activity Number: 123052 (Expires 01/02/2019)

Date Completed: 
CPEUs Awarded: 4.0

Learning Need Code: 
CPE Level: 2

Provider Signature

*Refer to your Professional Development Portfolio Learning Needs Assessment Form (Step 2)

PROVIDER #: AM003

Continuing Professional Education Certificate of Attendance
-Licensure Copy-

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The Editor

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Susan Weiner, MS, RDN, CDE, CDN
OTCE Editor
susan@susanweinernutrition.com

Let us hear from you!