
Preface

Diabetes is a major public health problem in the United States and worldwide. An estimated 29.1 million children and adults (1 in 11 people) have diabetes, although only about 21 million have been diagnosed. In addition, the estimated number of persons with prediabetes in the United States was 86 million in 2012. Worldwide there are currently an estimated 415 million people with diabetes and only half are diagnosed. Astronomical growth in the number of people with diabetes is predicted between now and 2040 – when 642 million individuals with diabetes are expected. Cardiovascular disease is the leading cause of death in people with type 1 diabetes and type 2 diabetes.

The pandemic of diabetes, not withstanding the role of genetics, is largely preventable with meaningful changes in diet and physical activity. Exercise is recognized by leading authorities including the American Diabetes Association, the European Association for the Study of Diabetes, the American Association for Clinical Endocrinologists, the Endocrine Society, and the International Diabetes Federation and leading primary care groups as a cornerstone of diabetes prevention and treatment, yet still most people with or at risk for type 2 diabetes are not physically active. This is in part a societal issue, involving increased sedentary lifestyle (workplace, school, and home), a built environment that is not conducive to physical activity, and reduced norms for physical fitness plus physiological changes in people with diabetes that decrease exercise tolerance. In particular, women are more sedentary than men across the lifespan beginning with pubertal girls. Diabetes is also more common in people of color and low socioeconomic status among whom there is already a propensity toward lower physical activity. The prevalence of diabetes is higher among persons of Hispanic, African American, and Native American heritage than among persons of non-Hispanic white origins.

One reason people with type 2 diabetes are more sedentary than nondiabetic people is that there are some barriers which may be physiologic as well as socioeconomic. Persons with type 2 and type 1 diabetes have reduced exercise capacity, including lower maximal oxygen consumption and impairments in the submaximal measures of cardiorespiratory exercise performance. These exercise abnormalities appear early on in the course of type 2 diabetes and may be related to cardiac and hemodynamic abnormalities. Importantly, decreased physical fitness and increased sedentary activity correlate with cardiovascular and all-cause morbidity and mortality, which are already increased by diabetes. Implementation of safe and effective exercise programs for all

people with diabetes is essential for increased healthspan and prevention of cardiovascular disease.

The goal of our 2nd edition of *Diabetes and Exercise* is to give the researcher and practitioner in the area of diabetes evidence-based information that is both theoretically and clinically useful. We hope to facilitate further understanding of the importance of physical activity as part of the standard of care for diabetes management and prevention. We have invited experts in diabetes, diabetes prevention, integrative physiology, exercise physiology, and exercise implementation to inform the reader of the current state of the art. In addition, exercise guidelines and precautions are provided to maximize the benefits of activity and to minimize risk with physical activity interventions.

Part I: Epidemiology and Prevention This section sets the stage for the rest of the book. Drs. Rueggsegger and Booth highlight the current “state of fitness” and the implications of loss of fitness on the health of the individual and the population at risk for diabetes. Drs. Cusi and Sanchez-Portillo provide a sobering overview of the impact of obesity and sedentary behavior on fatty liver disease, and Drs. Nazare, Balkau, and Borel review the epidemic and physiology of metabolic syndrome. Prevention of diabetes is discussed by Dr. Perreault. In this section, the magnitude of the problems posed by diabetes are discussed to facilitate a deeper understanding of the compelling rationale for the use of exercise and increased physical activity in persons with and at risk for diabetes.

Part II: Physiological Effects of Exercise in Type 2 Diabetes In this section, the physiological interrelationships between diabetes, exercise capacity, and adaptations to exercise training are provided in seven chapters. We start with a synopsis of the current understanding of exercise performance in youth with diabetes by Drs. Nadeau, Baumgartner, and Gross. This is followed by an overview of the current knowledge on the impact of type 2 diabetes on exercise capacity in adults by Drs. Huebschmann, Reusch, Bauer, Regensteiner, and Schauer. In these two chapters, we provide a concerning picture of subclinical cardiovascular disease and diminished physical fitness even in youth and younger adults with apparently uncomplicated diabetes. Next, Drs. Kalyani, Quartuccio, Hill Golden, and Regensteiner highlight current knowledge on sex differences in diabetes and exercise, focusing on the worse impairments in women than men with diabetes. In order to inform the reader about the specific physiological effects of exercise and diabetes, the next few chapters examine the impact of exercise, in the context of diabetes, on mitochondrial function (Dr. Chow), endothelial function and inflammation (Drs. Roustit, Loader, and Baltzis), adiposity and regional fat distribution (Drs. Stewart and Dobrosielski), and muscle blood flow regulation (McClatchey, Bauer, Regensteiner, Reusch). This section presents a picture of how diabetes affects exercise capacity in women, youth, and adults and the multiple systems impacted by exercise training. We also highlight gaps in our current knowledge as to how diabetes changes exercise capacity and interferes with the adaptive responses to exercise training. This mechanistic information makes it possible to understand the reasons why

physical activity is especially important for people with diabetes. Thus, the concept of *exercise as medicine* has a strong scientific basis for prevention and treatment of diabetes.

Part III: Management and Treatment This section addresses practical issues that are essential in order to safely engage patients with diabetes in exercise-related research protocols and clinical programs. Drs. Barone Gibbs and Jakicic provide lessons learned and guidelines from Diabetes Prevention Program (DPP) and Action for Health in Diabetes (Look AHEAD) studies. Dr. Colberg discusses key concepts and guidelines on how to manage food intake with exercise to avoid low blood glucose and optimize safe, productive, and satisfying exercise programs. Critical behavioral issues that must be addressed to sustain exercise adherence in patients accustomed to sedentary behavior are reviewed by Drs. Bessesen and Bergouignan. This is followed by a chapter by Drs. Marcos Valencia and Florez on exercise, aging, and quality of life. Finally, Dr. Franklin discusses the medical evaluation and assessment that should be undertaken before beginning a program of exercise for persons with diabetes, including the value and limitations of exercise stress testing. Taken together, this section is a practical overview of the impact of exercise on diabetes prevention, treatment, and physical function along with some strategic advice on how to enable people with diabetes to incorporate sustainable and safe exercise practices into their lifestyles.

Part IV: Special Considerations for Exercise in People with Diabetes Throughout the previous sections, we highlight the excess premature mortality and cardiovascular disease common to people with diabetes. Diabetes is commonly associated with comorbid conditions that may interfere with exercise as reviewed by Drs. Mar, Herzlinger, Botein, and Hamdy. Drs. Schauer, Huebschmann, and Regensteiner present further detail on the interplay between exercise and macrovascular disease. New data on strategies to safely enable exercise and prevent hypoglycemia in people with type 1 diabetes are provided by Drs. Roberts, Forlenza, Maahs, and Taplin. Drs. Najafi, Patel, and Armstrong provide a pragmatic overview on how to facilitate safe exercise and optimal healing for individuals with diabetes-related lower extremity disease. Cardiac rehabilitation, absolutely critical for optimal outcomes in the context of diabetes-related cardiovascular disease, is discussed by Drs. Squires and Stewart. Our closing chapter highlights the issue of peripheral artery disease in people with diabetes and exercise recommendations by Drs. Mays, Whipple, and Treat-Jacobson. The theme of this section is that there are real barriers to exercise in people with diabetes. These experts provide compelling, evidence-based data showing that people with diabetes and comorbid conditions will benefit from physical activity, and they review strategies to safely exercise with comorbidities to improve outcomes and quality of life.

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