# Strength Training in Diabetes Management

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Aerobic exercise continues to be the prevailing mode of exercise endorsed for physical fitness and health. Current public health recommendations place a clear emphasis on aerobic activities.[1–3] The U.S. Surgeon General, the Centers for Disease Control and Prevention, and the American College of Sports Medicine (ACSM) all espouse encouraging the accumulation of 30 minutes of aerobic activity most days of the week.

Strength, or resistance, training has not enjoyed the same degree of popularity as aerobic exercise.[4] Strength training has continually suffered from its antiquated image as an odd, frivolous activity associated with dank gyms, Eastern bloc weightlifters, or narcissistic bodybuilders. Both the medical and exercise science communities long believed that strength training offered little in the way of health benefits, or worse still, considered it to be a detriment to good health.[5,6] It was not until 1990 that the ACSM included resistance exercise in its recommendations for achieving physical fitness.[7]

There is now a substantial and ever-growing body of evidence demonstrating the merits of strength training. When combined with aerobic exercise, some of the benefits are additive, whereas others are unique to strength training and cannot be achieved through aerobic activity alone. Many of these benefits may be particularly useful when employed in the management of chronic diseases such as diabetes. Health care providers, however, often remain unfamiliar, unconvinced, or both regarding recommendations for strength training exercise for their patients.

## Strength Training, Fitness, and Function

Physical fitness is composed of several components, including cardiorespiratory endurance, body composition, muscular endurance, muscular strength or power, flexibility, and balance/coordination. Each component of fitness has a unique role in the preservation of health. Whereas aerobic exercise primarily targets the cardiorespiratory endurance component, strength training appears to play a prominent role in many, if not all, of the other six components to physical fitness. In doing so, strength training has unique potential in helping to arrest much of the functional decline and disease progression associated with aging.

Much of the research involving strength training has focused on its role in the prevention of the age-related loss of skeletal muscle mass and subsequent loss of strength and function, a phenomenon known as sarcopenia. Although the development of sarcopenia is multifaceted, physical inactivity clearly accelerates the process. A physically inactive adult can expect to lose 3–5% of muscle mass and strength per decade after the age of 40 years.[8,9] The muscle atrophy associated with sarcopenia occurs primarily in the so-called fast-twitch skeletal muscle fibers. This type of fiber is recruited during higher-intensity, anaerobic work, such as that accomplished through strength training.

Strength is intrinsic to daily functioning and quality of life. Muscular strength has been independently associated with functionality,[10–12] and a loss of skeletal muscle mass and strength has been associated with a decline in health status.[10] Adequate muscle mass and strength are necessary for performing activities of daily living, including not only such basic tasks as getting dressed, but also walking, climbing stairs, carrying groceries, and performing the countless other tasks necessary to maintain a home or yard. Strength is also a fundamental requirement for innumerable recreational activities, including shopping, traveling, accompanying grandchildren to a park or zoo, or participating in recreational sports. Spontaneous levels of physical activity have, in fact, been shown to parallel increases in strength in the elderly.[13] A certain level of strength is even a prerequisite for participation in many aerobic-type activities.

Strength training has been clearly demonstrated to result in muscle hypertrophy and improved muscular strength and power.[14–16] Improvements in muscular strength and power observed with strength training have translated into improved walking mechanics, speed, and endurance, as well as improved stair-climbing power.[17,18] Additionally, strength training has been shown to be of benefit in osteoarthritis and of possible benefit in osteoporosis, dynamic balance, and flexibility.[14,19,20] Although A-level outcome data are currently lacking, the research to date is overwhelmingly suggestive that, given its abilities in ameliorating such risk factors, strength training is an important intervention for the prevention of falls and disability in the elderly.

## Strength Training and Metabolic/Cardiovascular Disease Risk Factors

In addition to its role in preserving musculoskeletal function and inde-

pendence in the elderly, strength training has been shown to favorably influence several metabolic and cardiovascular disease (CVD) risk factors that were traditionally thought to be exclusively associated with aerobic exercise. Research has supported strength training as being comparable to aerobic exercise in ameliorating CVD risk factors for more than a decade now, in fact.[21] The exact role of strength training in the primary and secondary prevention of CVD continues to be examined, but the evidence thus far suggests strength training can be a safe and effective adjunct.[22,23]

A recent study published in the *Journal of the American Medical Association* involving 452 men followed for 12 years also showed that the reduction in coronary heart disease (CHD) risk associated with weight training was equivalent to that of aerobic activities such as running, rowing, and walking.[24] The authors further concluded that because of the apparent inverse dose-response relationship between total physical activity and risk of CHD, adding weight training to an existing aerobic exercise program is among the most effective strategies to reduce the risk of CHD.

**Insulin resistance**

Aerobic exercise long has been recommended in the management of type 2 diabetes, in large part because of its ability to improve insulin sensitivity and glucose tolerance.[25] Several studies have suggested, however, that strength training is similarly efficacious at improving insulin sensitivity and glucose tolerance when compared to aerobic training.[26–29]

Even more compelling is the evidence demonstrating the additive effects of combining aerobic and resistance exercise on insulin sensitivity and glucose metabolism. Incorporating both types of activity appears to take advantage of differing mechanisms of action, enhancing insulin sensitivity and glucose disposal further than either activity could achieve alone.[30,31] This is exciting news for patients with type 2 diabetes who have already exhausted diet and aerobic exercise as their means of managing the disease through lifestyle efforts.

**Blood pressure**

Blood pressure is another CVD risk factor for which aerobic activities have long been the only type of exercise advocated as a management option. Strength training not only was not recommended for management of hypertension, but also was considered detrimental based on limited, early research.

A recent meta-analysis of randomized controlled trials concluded, however, that "progressive resistance exercise is efficacious for reducing resting systolic and diastolic blood pressure in adults."[32] Although the authors admit that reductions in blood pressure are modest, this study effectively disputes the myth that strength training is a detriment to blood pressure control.

The authors of this study also correctly point out that the data pertaining specifically to hypertensive subjects are somewhat limited. However, the existing evidence demonstrates that hypertensive subjects will benefit similarly from strength training.[33,34] Viewed collectively, the current data therefore suggest that patients with hypertension can safely participate in, and likely benefit from, strength training.

**Truncal obesity**

It is known that obesity is a predictor for both type 2 diabetes and metabolic syndrome. More recent data suggest that obesity, specifically truncal obesity, may in fact be the primary predictor of the metabolic syndrome.[35] It is theorized that much of the ensuing metabolic disruption, including insulin resistance and dyslipidemia, stems from alterations in free fatty acid metabolism resultant from truncal obesity.[36,37]

Regardless of how it is achieved—whether through calorie restriction, aerobic exercise, strength training, or any combination of lifestyle factors—a reduction in truncal obesity appears to improve this metabolic disruption.

While calorie restriction and/or aerobic exercise are effective at inducing weight loss and reducing truncal obesity, lean body mass (skeletal muscle tissue) is typically sacrificed in the process.[13] When strength training is included as part of the weight loss regimen, however, lean body mass can be simultaneously maintained or gained.[38] This may prove to be especially advantageous in the long-term management of type 2 diabetes and the metabolic syndrome.

Increased lean body mass has been independently associated with improved insulin sensitivity,[31] possibly because it provides additional glycogen storage capacity or other postulated mechanisms. Resting metabolic rate (RMR) is also largely related to levels of lean body mass. Increasing levels of lean body mass via strength training has been demonstrated to have a favorable effect on RMR.

The limited, current research does not support the notion that preserving muscle mass via strength training while dieting will preserve RMR in the short term (8- and 12-week studies).[38,39] The consequences incurred from years (or decades) of so-called "yo-yo dieting" with subsequent depletion of muscle mass and perpetually diminishing RMR, however, have not been adequately investigated. Given its known contribution to RMR, most experts believe that maintaining muscle mass is fundamental for the long-term management of obesity. Additionally, as the sarcopenia data have demonstrated, preserving skeletal muscle mass is imperative for maintaining levels of physical activity, function, and independence, all of which are necessary in the long-term management of obesity.

**Promoting Strength Training**

Despite the impressive data demonstrating innumerable benefits that have great applicability in the management of chronic diseases such as diabetes, strength training continues to receive only brief mention in published guidelines. The promotion of exercise will ultimately continue to rely on frontline health care providers. The great majority of patients cite their health care providers as their primary source of information regarding healthy lifestyle decisions, and there is encouraging evidence suggesting that counseling patients on exercise does lead to increased exercise participation and levels of physical activity. Therefore, it is up to providers to promote the use of exercise in general, and strength training in particular.

Health care providers cite inadequate time and inadequate knowledge or experience as the most common reasons for not counseling patients on exercise. Time constraints will likely remain a ubiquitous problem in health care. When you consider the overall burden of chronic disease, along with the substantial benefits, minimal risks, and minimal costs involved with increasing levels of physical activity, however, it can be argued that exercise counseling should receive adequate priority.

Additionally, lacking familiarity with exercise need not be an insurmountable excuse for not recommending and prescribing exercise to patients. Research has demonstrated that health care providers who exercise themselves are more likely to counsel their patients on exercise. Similarly, providers who participate in aerobic or strength training are more likely to recommend and prescribe those types of exercise. It would appear that the first step in getting patients to participate in aerobic or strength training exercise is getting health care providers to participate themselves.

**Summary**

Aerobic exercise will, understandably, likely remain the most recommended mode of exercise. Aerobic activities (such as brisk walking) are safe, are familiar to patients, require little skill or equipment, and can be performed anywhere, facilitating participation. Epidemiological and interventional data have unequivocally demonstrated the benefits of aerobic exercise in the prevention and management of several chronic diseases, most notably type 2 diabetes and CVD.

Strength training, however, is the only type of exercise that has been demonstrated to halt or reverse sarcopenia, reliably increasing muscle mass, strength, and power. Research during the past several decades has confirmed several additional benefits of strength training, including increasing bone mineral density, increasing endurance performance, normalizing blood pressure in prehypertensive patients, reducing insulin resistance, decreasing both total and intra-abdominal fat, increasing resting metabolic rate, reducing risk factors for falls, and reducing pain and improving functioning in patients with osteoarthritis.[19,20]

Preserving musculoskeletal function, independence, and subsequent quality of life is a universal goal for all patients. The favorable metabolic effects observed with strength training suggest, however, that this type of exercise may be particularly well suited for the management and prevention of both metabolic syndrome and type 2 diabetes, as well as the atherosclerotic vascular disease that accompanies these conditions.

Given the rates of obesity and type 2 diabetes and the contribution of a sedentary lifestyle on these diseases, an increase in any type of physical activity should be resolutely encouraged among patients. Strength training is a reasonable alternative for patients whose barriers, real or perceived, preclude them from participation in aerobic exercise. For patients who have been participating in aerobic-type activities exclusively, strength training provides benefits that are both novel and additive. Such benefits underscore strength training's contribution to diabetes management and overall wellness.

**Strength Training Primer**

Strength training is synonymous with resistance exercise or progressive resistance exercise. Strength training therefore implies muscle movement against resistance, such as weights, rubber tubing, or one's own body weight against gravity. Strength training movements are of a higher intensity and briefer duration than aerobic-type activities. Intensity is often measured as a percentage of an individual's one repetition maximum (1RM). Intensities of 60–90% 1RM are typically utilized in strength training programs, although the initial resistance used may be as low as 30%. Patients can also be instructed to achieve a "comfortably hard level" of exertion (13–15 on the Borg Scale of Perceived Exertion)[40] as an alternate method of quantifying intensity.

As an individual's strength increases with proper training, a progression in the overload placed on the muscle needs to occur to sustain further improvement. This is typically accomplished by increasing repetitions and/or resistance. This type of exercise training places unique stress on the musculoskeletal system, which in turn causes an anabolic adaptation response in both muscle and bone. Aerobic training does not elicit such a response.

**Exercise prescription**

A typical strength training program involves one to three sets of several different exercises targeting the major muscle groups, including quadriceps, hamstrings, gluteals, latissiumus dorsi, pectorals, and deltoids. Additional exercises can be added for smaller muscle groups, such as biceps, triceps, trapezious, or calves if time allows. Repetition ranges are typically 8–15 per set. Repetitions are performed in a strict and controlled manner, and full range of motion should be attempted if pain is not a limiting factor. Attention must be given to proper lifting mechanics, and breathing patterns should remain normal to avoid the Valsalva maneuver. Rest intervals between sets typically last 1–2 minutes, allowing a strength training session to be completed in 20–30 minutes.

Compound, multiple-joint exercises are generally recommended over single-joint, isolation-type movements. As patients develop improved strength and coordination, free-weight or body weight movements can also be incorporated. Such movements challenge patients with dynamic movement and increased need to balance and may improve kinesthetic awareness and further support gains in functional strength above and beyond exercises relying on fixed-axis weight machines, which operate in a single plane of movement.

Strength training may be performed up to 2–3 times per week. If the same muscle groups are to be trained, individual workout sessions should be separated by a minimum of 48 hours. There are, of course, innumerable variations that may be incorporated as experience and familiarity grow, or to individualize the program to a patient's specific needs or limitations.

**Safety considerations**

Strength training has been demonstrated to be safe and effective in

patients with chronic diseases, including diabetes and CVD. Because of the significant complications and comorbidities that may be associated with diabetes, however, individual patient considerations must be taken into account when prescribing exercise. Ideally, the health care team should be involved in assessing and recommending exercise for patients with diabetes.

Absolute contraindications to strength training include unstable angina, uncontrolled hypertension, uncontrolled dysrhythmias, hypertrophic cardiomyopathy, and certain stages of retinopathy. Patients with congestive heart failure, myocardial ischemia, poor left ventricular function, or autonomic neuropathies must be carefully evaluated before initiating a strength training program. Several articles have addressed the unique exercise needs of patients with diabetes or CVD.[22,41]

**Maximizing patient success**

Patients require access to a safe, friendly environment in which to exercise, ideally staffed by knowledgeable exercise professionals. Health care providers can help by creating a comprehensive list of resources within their organization or within the community for referral. Many exercise facilities have staff qualified to work with patients with special needs. Further, many will go out of their way to build relationships with health care providers interested in encouraging patients to exercise. Your list of resources should also include options for those patients who elect to exercise at home.

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