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The Effect of Exercise on Insulin Resistance

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Introduction

The prevalence of diabetes mellitus (DM) is striking. It is estimated that more than 360 million will develop DM by 2030 (Fauci et al., 2008). According to the Center for Disease Control and Prevention (CDC), 7.8% of the United States population had DM in 2007. The total estimated cost of DM in 2007 was $174 billion dollars (CDC). It is the leading cause of end stage renal failure, nontraumatic lower extremity amputation and adult blindness in the United States. DM will continue to be a chief cause of morbidity and mortality in the projected future, its magnitude deeply significant (Fauci et al., 2008).

There are geographic, ethnic, and age variations in the prevalence of DM. In the United States, the onset of type 2 DM is earliest amongst certain ethnic groups (Fauci et al., 2008). In 2005, the prevalence of DM was 15.1% in Native Americans, 13.3% in African Americans, 9.5% in Latinos, and 8.7% in non-Hispanic whites (CDC). By 2030, ages 45-64 years will have the highest percentage of DM than any other age category (Fauci et al., 2008). Worldwide, Scandinavia has the largest prevalence of type 1 DM; the United States has an intermediate prevalence, and the Pacific Rim nations (Japan and China) have a low prevalence. The highest prevalence of type 2 DM lies in certain Pacific islands; the United States has an intermediate prevalence, and Russia has a low prevalence (Fauci et al., 2008). Ethnic and age variations are important when considering management options.

DM refers to a group of metabolic disorders, characterized by hyperglycemia. Hyperglycemia is caused by a complex interplay of genetic, immunological, and environmental factors. But generally, hyperglycemia is due to impaired glucose utilization, abnormal insulin production, and increased glucose production. Metabolic dysregulation of glucose and insulin often leads to secondary multisystem pathology. Chronic complications of DM include:

retinopathy, nephropathy, neuropathy, coronary artery disease, peripheral arterial disease, cerebrovascular disease, infections, and skin changes (Fauci et al., 2008). Therefore, the prevention, proper diagnosis, and treatment of DM have a profound impact on the quality of life and financial well being for the individual, community, and health care system.

Abnormal insulin production is an essential component to the complexity of DM and deserves further explanation. Insulin is a hormone, which can have varying degrees of functionality. It is synthesized by beta cells in the pancreas, known as the islets of Langerhans. After synthesis, insulin is secreted in response to increased serum glucose. Insulin promotes glucose uptake from serum into the cells of target tissues, effectively maintaining normal serum glucose. Insulin works to conserve energy and build energy stores. (Lehne, 2004). Ultimately, insulin is the key to normal serum glucose.

But there are varying degrees of insulin effect on cells. Insulin resistance (IR) describes the reduction of insulin to act on target tissues, such as; muscle, fat, and liver. The exact molecular action leading to IR is not yet understood. IR is caused by a combination of obesity and genetic susceptibility. IR is an especially important metabolic abnormality as it is a major characteristic in type 2 DM and is also applicable to type 1 DM (Fauci et al., 2008). IR further perpetuates the chronic sequela of secondary multisystem pathology and it is an important process to consider when managing DM.

As discussed above, DM is classified into two broad categories: type 1 and type 2. Each classification has unique characteristics. Type 1 DM is near or total insulin deficiency. Insulin deficiency is due to the destruction of pancreatic beta cells, most often by an autoimmune response and less frequently by an unknown mechanism. Islet cell autoantibodies (ICAs) are responsible for the destruction of pancreatic islet cells. ICAs are present in more than 75% of those diagnosed with new-onset type 1 DM. About 80% of beta cell destruction occurs before type 1 DM becomes clinically evident. Residual beta cells continue to exist in a number of type 1 individuals and these individuals continue to retain some level of insulin productivity, before total depletion occurs. The rate of total beta cell destruction varies considerably and residual beta cells differ in their ability to produce insulin (Fauci et al., 2008). Even though IR is highly variable, it is an influencing factor in type 1 DM nonetheless.

Type 2 DM is a group of disorders that vary in degree of IR, abnormal insulin secretion, and increased glucose production. IR is a prominent characteristic in type 2 DM, playing a large role in hyperglycemia. IR impairs the uptake of glucose by insulin sensitive tissues (muscle, fat, and liver), leading to an increase in hepatic glucose output and serum glucose. Insulin secretion is also impaired in type 2 DM. The secretory defect eventually becomes inadequate, again, leading to hyperglycemia. IR, abnormal insulin secretion, and increased glucose production work together to create a dramatic impact. Furthermore, obesity is particularly common in type 2 and its impact is serious. Unfortunately, increasing obesity and decreasing activity, are escalating the worldwide prevalence of type 2 DM (Fauci et al., 2008).

Hyperglycemia is problematic and the management of DM is complex. Lifestyle modifications and medication play a major role in maintaining normal serum glucose. Interventions can be initiated to decrease or eradicate chronic secondary multisystem pathology. For example, exercise has historically been recommended as a method to control hyperglycemia (Fieback, Kern, Thomas, Ziegelstien, Barker, and Zieve, 2007). Exercise offers abundant benefits to everyone: improved cardiovascular health, muscle mass maintenance, and body fat reduction. There are unique advantages of exercise for diabetics. Exercise is effective in decreasing blood glucose, both during and following physical activity. In fact, exercise may lower plasma glucose levels, decrease IR, and prevent the onset of type 2 DM (Fauci et al., 2008).

According to Gill and Cooper, a high level of activity can reduce the risk of acquiring DM by 20%-30%. This may be due to the subsequent effect exercise has on adipose tissue. The greatest risk reduction is associated with those at high risk: obese, positive familial history, and impaired glucose utilization (2008). Furthermore, weight loss can invoke greater sensitivity to endogenous insulin and normalize serum glucose in obese IR individuals. Such a scenario may lead to the discontinuation of DM related pharmacological measures. Therefore, exercise induced weight loss and improved IR has the potential to prevent type 2 DM or obviate the need for DM related pharmaceuticals (Fieback et al., 2007).

Numerous exercise guidelines are available. For example, the American Diabetes Association (ADA), the American College of Sports Medicine, and the American Heart Association recommend "that adults participate in at least 150 minutes of moderate-intensity physical activity or 60-90 minutes of vigorous activity per week to reduce the risk of cardiovascular disease and type 2 diabetes" (Gill and Copper, 2008, p. 808). Such exercise guidelines tend to be one-size-fits-all. One-size-fits-all exercise guidelines fail to count numerous variables which may affect persons with DM (Gill and Cooper 2008). Therefore, exercise guidelines need to be modified by health care providers to address individual need. Properly designed exercise guidelines are essential for appropriate treatment and successful outcomes.

Literature review

There is a vast amount of literature concerning DM and its implications. In a meta-analysis by Snowling and Hopkins, twenty-seven controlled trial studies were included. Eighteen were randomized, eight were controlled trials and one was a randomized crossover trial. Their method included searching PubMed and SportDiscus databases for articles that were published in English, up to the year of 2006. Only controlled trials with supervised exercise programs for type 2 diabetics were eligible. Furthermore, studies needed to include at least one measure of glucose control (HbA1c, fasting glucose, postprandial glucose, fasting insulin and insulin sensitivity). Moreover, the researchers analyzed the following risk factors: body mass, fat mass, blood lipids and blood pressure (2006).

With exercise as the independent variable and IR as the dependant variable, Snowling and Hopkins attempted to meta-analyze different modes of exercise and its effect on blood glucose control. There were a total of 1,003 type 2 diabetics between the ages of 48-62. The studies were done between 5-104 weeks and addressed aerobic training, resistance training, and combined training. The result was from the weighted means of outcome statistics from each study. Finally, the meta-analysis was performed in SAS version 8.2 (2006).

Snowling and Hopkins report evidence that suggests individuals maintaining regular physical activity have a reduced likelihood in developing IR, type 2 DM, and impaired glucose tolerance. The effect of exercise (aerobic, resistance and combined training) on glucose control (HbA1c) was statistically significant. Evidence also suggests there is an additional benefit of exercise when the disease is more severe. Finally, a reduction in HbA1c 0.8 +/- 0.3% at a +/-90% confidence limit resulted from the effect of exercise (Snowling and Hopkins, 2006).

As a meta-analysis with twenty-seven controlled trials this study offers great strength. But compliance with exercise was a weakness. Twelve studies did not address exercise attendance. Despite this, there is clinical significance, exercise leads to small to moderate benefits in glucose control. Snowling and Hopkins compare the beneficial effects of exercise to those of diet and medication. This evidence supports exercise recommendations for DM (2006).

A systematic review, by Gordon et. al, included twenty studies. Thirteen were randomized controlled trials, eight were controlled trials without randomization and three were uncontrolled studies. Medline and Embase databases were searched to locate studies with the following key variables: English language, subjects 18 years and older with type 2 diabetes, resistance training as an isolated intervention, and at least one diabetes marker (HbA1c, fasting glucose or insulin, insulin sensitivity or insulin signaling outcome report) (2008).

Gordon et. al sought to review literature on the effects of resistance training on insulin sensitivity in type 2 diabetics. The independent variable is resistance training and the dependant variable is insulin sensitivity (measured by glycemic control). Most studies used supervised resistance training machines, done on 3 nonconsecutive days each week. The training intensity and duration of resistance training in each study varied (2008). The results were divided into the following groups: glycemic controls, insulin sensitivity, insulin signaling, muscle strength, body composition and cardiac risk factors. The review suggests that type 2 diabetics can perform resistance training with minimal risk. More specifically, resistance training decreased HbA1c by 0.6%. Two studies utilized the euglycemic-hyperinsulinemic clamp, considered the gold standard for measuring insulin sensitivity, and found increased insulin sensitivity (Gordon et. al, 2008).

Since resistance training improves HbA1c, it is an important consideration in developing exercise guidelines for DM. Clinicians can consider prescribing resistance training to their diabetic patients. There are organizations that offer resistance training guidelines, such as the

ADA and American College of Sports Medicine. Unfortunately, the researchers found compliance would decrease without supervision (Gordon, et. al, 2008).

An experimental design, by Brestoff, et. al, was conducted by a laboratory for five consecutive weeks. Endurance exercise (EE) and sprint interval exercise (SIE) is the independent variable and insulin sensitivity is the dependant variable. The study compared insulin sensitivity before and after intense sessions of EE and SIE. There were fifteen volunteer subjects, five female and eight male from an east coast college. All subjects were healthy, nonsmokers, and of stable weight. The subjects were free from metabolic or cardiovascular disease. All data was analyzed using SPSS-14.0 and ANOVA was used for a repeated measures analysis (2008).

The following variables were measured throughout the study: determination of VO2 peak and ~75% VO2 peak verification, ~75% peak endurance ride, supra-maximal ~125% VO2 peak sprint interval familiarization and testing, oral glucose tolerance test (OGTT), plasma glucose and insulin assay, and IL-6 and TNF-alpha assay. Results showed whole-body insulin sensitivity was improved after a 45 minute session of ~75% VO2 peak EE, but not after supra-maximal ~125% VO2 peak SIE. Although, subjects lacked DM, Brestoff, et. al suggest insulin sensitivity in those with DM may improve with exercise at ~75% VO2 peak. The results appear to be clinically significant, since they support exercise as having a positive effect on IR (2008).

A controlled clinical trial, by Bonen, et. al, attempted to compare the effects of low and high intensity exercise on OGTT. The independent variable is exercise (low and high intensity) and the dependant variable is glucose tolerance. There were ten subjects, five males and five females, ages 40-48. Subjects were free from disease, did not take medications, and were not physically active prior to the study (1998).

Data was gathered as each subject participated in five exercise sessions. A fasting OGTT was done several days before exercise was started, immediately after exercise, and 24 hours after exercise. Blood samples were also used to measure glucose and insulin during specific time intervals. The incremental glucose and insulin levels were calculated using a computerized algorithm with the trapezoid rule. These data were further analyzed with repeated measures of analysis of variance (Bonen, et. al, 1998).

The study suggests exercise improves glucose tolerance, lasting up to 24 hours after exercise. Furthermore, low and high intensity exercise had a similar benefit on glucose tolerance. Maximum benefits resulted when subjects exercised in 20-30 minute intervals, at heart rates of 105-145 bpm. Although, the sample size was small, exercise appears to have positively affected OGTT, an important indicator in managing DM. Bonen, et. al, provides reassuring evidence to clinicians who prescribe exercise (2008).

In 2008, Gill and Cooper presented the concept of one-size-fits-all exercise guidelines. They reviewed prospective cohort studies and controlled intervention trials for evidence of exercise guidelines designed for different populations and prevention of type 2 DM. They investigated various intensities and types of exercise from twenty prospective cohort studies and several controlled clinical trials (a number of these were randomized). They recommend exercise guidelines be modified depending on the patient. Variations such as high/low risk, familial history, obesity, and race need to be considered when designing exercise guidelines (2008).

Gill and Cooper searched MEDLINE for: English language, type 2 diabetes, exercise, physical activity, walking, sports, fitness, and lifestyle. Diet and lifestyle combinations were excluded. Twenty studies were cohorts and six were large scale prevention intervention trials.

The subjects were between the ages of 40-66 and were followed for 4-26 years. Most exercise interventions varied between vigorous, moderate, and light activity. Studies were presented in table format, listing: country, subjects, physical activity assessments, and main findings (2008).

Gill and Cooper suggest an inverse relationship between diabetes risk and physical activity. The longitudinal cohort studies propose physical activity is a protective factor against the development of type 2 diabetes. The prevention trials had similar results. Therefore, the risk of acquiring DM decreases with physical activity. But healthcare providers are prescribing one size-fits-all exercise guidelines. To promote positive outcomes, clinicians must consider the patient's unique individual characteristics when prescribing exercise.

A review of the literature has illuminated a relationship between exercise and IR. Exercise decreases IR and is an important management modality in the treatment of DM. For example, the Diabetes Prevention Program found individuals with impaired glucose tolerance who made lifestyle adjustments (dietary changes and thirty minutes of exercise five times a week) delayed or prevented the onset of type 2 DM by 58%, compared to placebo. These results were consistent, regardless of age, sex, or ethnicity (Fauci et al., 2008).

A review of the literature also reveals knowledge gaps. The exact mechanism of how exercise affects IR is not explained. Speculation of exercise induced weight loss and change to adipose tissue was the only explanation, which is vague in the least. Future research is needed to evaluate what form of exercise and duration of exercise (EE, SIE, low intensity, moderate intensity, high intensity, and resistance training) has the greatest impact on IR. Form and duration of exercise also needs to be measured in combination with individual characteristics (obesity, activity level, low/high risk, and age). Compliance and behavior modification would add an additional benefit when evaluating exercise. Encouragement, education, and supportive provider patient relationships may also add vitality to future studies. Again, incompatible exercise guidelines are discouraging. Future research may lead to improved exercise guidelines, decreasing IR for more patients with DM.

Exercise Guideline Recommendations

<u>Exercise information all individuals with DM should know:</u>

- Engage in regular aerobic activity for 30 minutes per day, most days of the week.
- Do not wait longer than 48 hours between exercise sessions, as improved insulin sensitivity is lost after 48 hours.
- Visit your healthcare provider to discuss an exercise plan and exercise tolerance test. Diabetes is considered a coronary heart disease equivalent and other risk factors need be identified. Risk factors include: age, general physical health, exercise history, orthopedic history and musculoskeletal risks, medication use, history of pulmonary disease, anticipated type of exercise, handicaps, and disabilities (Peterson, Fletcher, and Sokol, 2010).
- Regard exercise as important as insulin and nutrition. Exercise should be considered an equal partner in the quest for normal serum glucose.
- Plan a consistent exercise routine and exercise at similar times every day. These adjustments may help with consistent results while allowing for a regular pattern of mealtime and insulin.
- Endpoints of exercise should include: breathlessness, fatigue, and sweating.
- Monitor blood glucose before, during, and after exercise.

- Delay exercise if blood glucose is >14 mmol/L (250 mg/dL) and ketones are present
- When blood glucose is <5.6 mmol/L (100 mg/dL), ingest carbohydrate before exercising
- Monitor glucose during exercise. Ingest quickly absorbed carbohydrate to prevent hypoglycemia, such as: glucose tablets, hard candy, or juice.
- Decrease insulin doses (based on previous experience) before exercise and inject insulin in a site other than the exercising muscle. To start, decrease insulin dose by 30 percent before exercise and monitor results.
- Learn individual glucose response to different types of exercise. May need to increase food intake for up to 24 h after exercise, depending on intensity and duration of exercise (Fauci et al., 2008, p. 2295).

<u>Exercise Guidelines (ages 18 and older)</u>

- Moderate aerobic activity routines should include a total of 150 minutes of moderate-intensity activity (such as brisk walking or playing softball) and 2 days of muscle strengthening (such as heavy gardening, weights, or resistance band exercises) per week.
- Vigorous aerobic activity routines should include a total of 75 minutes of vigorous-intensity aerobic activity and 2 days of muscle strengthening per week.
- An example of a mix of moderate and vigorous aerobic activity routine includes the following: 90 minutes moderate-intensity aerobic activity and 30 minutes of vigorous-intensity aerobic activity and 2 days of muscle strengthening per week (CDC, 2011).

<u>Exercise Guidelines and limited mobility (such as obesity and/or disability)</u>

- Health benefits of exercise outweigh the risk.
- Taylor the above exercise guidelines to your individual specificities, or limitations.

- Find something you enjoy while feeling both competent and safe.
- Exercise can be performed in short duration several times a day. It can be integrated into daily life and broken down into 10 minute intervals.
- Evaluate individual risks and set appropriate goals (Peterson, Fletcher, and Sokol, 2010).
- Intensive lifestyle interventions can lead to significant weight loss and improvements in cardiometabolic risk in severely obese persons (Goodpaster, B., et. al. 2010).
- Examples of exercise include the following: brisk walking, gardening, mowing the lawn, shoveling, water aerobics, dancing, and swimming.
- Reduction in abdominal fat decreases hepatic steatosis which is largely associated with insulin resistance and an increased risk of cardiovascular disease (Goodpaster, B., et al. 2010).

Behavior change modification

Expecting an individual newly diagnosed with DM, to make immediate and dramatic lifestyle changes is unreasonable. While expecting one to behave remarkably different from one's history is also unrealistic. Nonetheless, providing encouragement and promoting realistic changes in conjunction with a nurturing relationship is significant. According to Fieback et. al., the practitioner-patient relationship is influential in the educational process. Education does not simply involve patients' compliance with a provided treatment plan. In fact, quality education is the provision of skills, attitudes, and knowledge, which will in turn empower the patient to make educated decisions and choose healthy behaviors (2007). The following lists address interventions involving behavioral, motivational, and empowerment strategies.

"Intervention: Behavioral Strategies

Involve patients in

Developing management plans

Self monitoring

Simplify treatment regimen.

Tailor treatment regimen to fit patients' characteristics and environment.

Implement complex treatment regimen in a stepwise or graduated manner (shaping).

Manage behavioral stimuli (cues).

Use reinforcements.

Enlist support from family, friends, workplace.

Increase supervision" (Fieback et. al., 2007, p. 51).

"Intervention: Motivation and Empowerment Strategies

Help the patient adopt new beliefs, attitudes, and values.

Target education to fill gaps in knowledge base, correct misconceptions, provide explanations that are understandable and acceptable to the patient, and motivate the patient in the context of the patient's value systems.

Use fear-and-benefit messages appropriately (relevant, accurate, connected to a treatment plan that is effective and feasible for the patient).

Point out current/past patient beliefs, attitudes, and behaviors that are congruent with the desired new beliefs, attitudes, and values.

Set agreed-upon goals.

Enhance patient self-perceptions (self-efficacy, locus of control).

Project a positive attitude about patients abilities to change.

Emphasize past and present behaviors that demonstrate self-control.

Help the patient take credit for changes that have been accomplished.

Reframe "failures" as successes.

Facilitate new skill development.

Involve the patient in the development of management strategies.

Facilitate problem solving by the patient.

Facilitate the development of specific, achievable behavioral objectives by the patient.

Facilitate the development of self-monitoring skills" (Fieback et. al., 2007, p. 53).

Clinical work-up

Diagnostic criteria for DM are issued by the National Diabetes Data Group and the World Health Organization. Because the medical, financial, and emotional implications of DM are great, the diagnostic criteria should be followed rigorously (Fauci et al., 2008). Criteria for the diagnosis of DM are listed by the ADA as follows: symptoms of diabetes plus random blood glucose concentration greater or equal to 11.1 mmol/L (200 mg/dL) or fasting plasma glucose (no caloric intake for 8 hours) greater or equal to 7.0 mmol/L (126 mg/dL) or two hour plasma glucose greater or equal to 11.1 mmol/L (200 mg/dL) during an OGTT (2007). According to Fauci et al, fasting plasma glucose is the most reliable and convenient test (2008).

Because the prevalence of DM is ever increasing, proper screening is crucial. Fasting plasma glucose is the recommended screening tool for type 2 DM because many individuals are asymptomatic. At the time of diagnosis, up to 50% of diabetics may have one or more diabetes-related complications. Type 2 DM may exist up to a decade without diagnosis. Yet early treatment can prevent complications. Therefore, screening is suggested every three years after the age of 45, earlier for the individual with a body mass index greater than 25 km/m^2 and with one additional risk factor (familial history, obesity, sedentary lifestyle, race, previous impaired fasting plasma glucose or glucose tolerance, gestational DM, hypertension, vascular disease, polycystic ovarian syndrome, and elevated HDL/triglyceride) (Fauci et al, 2008). Fieback et. al report that most DM diagnoses are made when individuals are asymptomatic due to routine screening (2007). Screening is a powerful tool to utilize. The diagnosis of DM comes with a heavy burden, but proper treatment may prevent or eradicate multisystem secondary pathology.

In clinical work-up, classification is important for the proper labeling and treatment of DM. Type 1 DM usually develops in childhood and is characterized by insulin dependency. Without insulin, ketosis acidosis ensues. Again, type 1 DM is a chronic autoimmune disease, which is often influenced by environmental factors (Fieback et. al., 2007). Although current evidence remains inconclusive, viruses, bovine milk proteins, and nitrosourea compounds have been identified as possible environmental triggers (Fauci et al, 2008).

Type 2 DM, often termed "metabolic syndrome," is a state of hyperinsulinemia, with or without hyperglycemia. The hyperinsulinemic state also indicates the occurrence of IR. Type 2 DM is associated with several abnormalities including, obesity, hypertension, and premature cardiovascular atherosclerosis. Type 2 DM is the most pervasive type (Fieback et. al., 2007).

Although, classification is important, it may take several years to properly assign. Each type can mimic the other. There are also several subtypes of DM. Latent autoimmune diabetes in adults refers to individuals who acquire ICA's without developing DM for years. They also tend to have a lengthy period of hyperglycemia, without the occurrence of ketoacidosis. Additionally, young people without ICA's may have developed maturity-onset diabetes of the young, a variation of type 2 DM. Furthermore, individuals with type 2 DM can exhaust beta cells, requiring total dependence on insulin. Strictly classifying individuals based on clinical criteria is unreliable (Fieback et. al., 2007). Therefore, healthcare providers must consider individual characteristics when classifying DM.

Treatment

Upon diagnosis of DM, the treatment options vary upon classification. Yet, the goals are similar for any classification; eliminate hyperglycemia and its symptoms, decrease or eradicate multisystem secondary pathology, and assist the individual in achieving a sense of normal living. There are several standards involved with optimal glycemic control. The first is to maintain an A1C of less than 7%. The A1C is a measurement of glycated hemoglobin. A1C quantifies a long-term measure of glycemic control, reflecting the average 120-day lifespan of erythrocytes. A1C, in turn, translates in mean plasma glucose. For example, an A1C of 6% is 7.5 mmol/L (135 mg/dL) mean plasma glucose. A1C should be obtained during both the initiation of care and throughout the duration of comprehensive care (Fauci et al., 2008).

The following lipid panels are also standard treatment goals: low-density lipoprotein less than 2.6 mmol/L (100 mg/dL), high-density lipoprotein greater than 1.1 mmol/L (40 mg/dL), and triglycerides less than 1.7 mmol/L (150 mg/dL). According to Fieback et. al., serum lipid abnormalities must be managed aggressively. In fact, individuals with type 2 DM have a twofold to fourfold risk of acquiring coronary artery disease. If lipoprotein levels are greater than 2.6 mmol/L (100 mg/dL), then lipid lowering pharmaceuticals should be prescribed (2007).

Diabetics should have a blood pressure less than 130/80 mmHg (Fauci et al., 2008). According to Fieback et. al., hypertension is common in DM. Type 1 individuals have a 5% increased risk of developing hypertension in ten years and a 33% increased risk in twenty years. Also, the risk of microvascular and macrovascular complications in all individuals with DM nearly doubles compared to their normotensive counterparts. If normal blood pressure is not maintained antihypertensive pharmaceuticals should be prescribed. Providers may also consider aspirin therapy. Because cardiovascular risk is great, antiplatelet therapy can be beneficial. Routine aspirin use in type 2 diabetics is supported for both safety and efficacy (2007).

DM is the leading cause of blindness, in ages twenty through seventy-four. Furthermore, DM-related complications also lead to other ophthalmologic pathology, such as retinopathy, hemorrhages, and microaneurysms. Therefore, an annual eye exam is necessary as a screening and preventative measure. Nephropathy also adds to the downward sequela of DM-related complications. Nephropathy is related to chronic hyperglycemia and involves structural changes in the glumerulus, hemodynamic changes in renal circulation, and the presence of microalbuminuria and macroalbuminuria. Annual screening for protein in urine, including a creatinine to estimate GFR is recommended. The optimal treatment for nephropathy is prevention with normal serum glucose. (Fauci et al., 2008).

Lower extremity complications, nontraumatic lower extremity amputation, foot ulcers and infections complicate matters. Lower extremity complications are due to neuropathy, peripheral arterial disease, and poor wound healing. An annual foot exam to assess blood flow, sensation, potential ulcer sites, deformities, and ankle reflexes is yet another important screening recommendation. Ultimately, the concept of comprehensive diabetes care highlights optimal therapy and involves much more than monitoring blood glucose levels (Fauci et al., 2008).

The following list is a guideline for comprehensive diabetic care. Each aspect must be considered in ongoing care because DM-related complications can be significantly decreased.

- “Self-monitoring of blood glucose (individualized frequency)
- A1C testing (2-4 times/year)
- Patient education in diabetes management (annual)
- Medical nutrition therapy and education (annual)
- Eye examination (annual)
- Foot examination (1-2 times /year by physician; daily by patient)
- Screening for diabetic nephropathy (annual)
- Blood pressure measurement (quarterly)

- Lipid profile and serum creatinine (estimate GFR) (annual)
- Influenza/pneumococcal immunizations
- Consider antiplatelet therapy" (Fauci et al., 2008, p. 2302).

Patient and family counseling

Learning that one has DM can lead to a remarkable emotional response. Some may not be surprised, recognizing their own symptoms in family members. However, anxiety and depression are common and providers need to be aware. DM is a chronic disease which may negatively impact quality of life. Many newly diagnosed individuals have difficulty living with the required changes which are necessary for optimal blood glucose control. These challenges can be viewed alone or collectively (Fieback et. al, 2007). To assist with the immediate educational and pharmacological requirements, each individual with DM necessitates a multidisciplinary team approach. A multidisciplinary framework for comprehensive diabetes care should ultimately be aligned to address individual and collective needs.

Members of the multidisciplinary team include the following: primary care provider and/or endocrinologist, diabetes educator, and nutritionist. Moreover, when and if complications arise, the team may include specialists, such as; nephrologists, cardiologists, and vascular surgeons. Therefore, a multidisciplinary framework for comprehensive diabetes care attempts to address all potentials (Fauci et al., 2008).

Family, social, cultural, employment, and financial concerns impact the management of DM. To mitigate the impact of these stressors, the individual with DM should identify sources of strength during episodes of emotional distress. With identified support systems and recurrent education, patients can gain greater responsibility for their care while increasing compliance. The most central element to a team approach is, of course, the patient (Fauci et al., 2008). Therefore, the individual with DM should be encouraged to participate, ask questions, comply, provide input, and demonstrate adequate self-care.

Finally, counseling should be part of comprehensive diabetic care. Supportive counseling can assist patients to cope with chronic disease. It includes patient family and friends, as these individuals may prove to be valuable resources to improve patient care. Healthcare providers establish a therapeutic relationship by displaying consistent interest and earning trust (Fieback et. al., 2007). Finally, counsel to patients with DM is open-ended; its benefits outweigh its cost.

Patient and family education

Education involves numerous aspects: exercise, nutrition, self- care during illness, pharmaceutical management (timing and correct administration of insulin), recognition of disease progression, recognition of hypo- hyperglycemia, and misconception clarification. Education is an essential and continual process. Education should be reinforced and encouraged at regular visits (Fauci et al., 2008).

Regarding nutrition, knowledge dissemination is essential. It involves coordinating caloric intake with diabetic pharmaceuticals, exercise, and if appropriate, weight loss. In type 2 DM, weight loss is often encouraged due to obesity. Proper nutrition can be difficult for anyone to achieve. Matching the proper caloric intake with the appropriate insulin dose is even more challenging. Self-monitoring blood glucose is a crucial piece to any insulin regimen. Carbohydrate counting is also utilized to determine value of meals and snacks. The carbohydrate value is generally used within a predetermined insulin-to-carbohydrate ratio to verify the necessary insulin bolus (Fauci et al., 2008). Due to the difficulty in achieving proper nutrition, patients' significant others may be asked to participate in nutrition education to increase patient compliance. Diet exchange lists and food equivalent lists may be helpful to diabetics learning new nutritional guidelines (Fieback et. al., 2007). The following list highlights nutrition recommendations for adults with DM (Fauci et al., 2008, p. 2295).

“Fat

- 20-35% of total caloric intake
- Saturated fat <7% of total calories
- <200 mg/day of dietary cholesterol
- Two or more servings of fish/week provide polyunsaturated fatty acids
- Minimal trans fat consumption

Carbohydrate

- 45-65% of total calorie intake (low-carbohydrate diets are not recommended)
- Amount and type of carbohydrate important
- Sucrose-containing foods may be consumed with adjustments in insulin dose

Protein

- 10-35% of total caloric intake (high-protein diets are not recommended)

Other components

- Fiber-containing foods may reduce postprandial glucose excursions
- Nonnutrient sweeteners”

Foot care is an additional aspect involving education. Minor foot problems, calluses, and nail deformities need to be assessed by a podiatrist. Daily foot inspections are recommended to prevent unnoticed foot dilemmas. Encouraging tobacco cessation is also crucial for in the diabetic population. Smoking increases the decline in renal function and accelerates the pathogenesis of diabetic nephropathy. Patients must also complete annual eye exams due to DM-related ophthalmologic complications, such as blindness and retinopathy (Fauci et al., 2008).

Alcohol is an additional area of concern, although it is subject to social, cultural, religious interpretations. Providers may be even more concerned about alcohol use when a patient has a history of alcohol abuse. Moderate alcohol use in men is associated with a decreased occurrence of type 2 DM. In women with DM, alcohol use is associated with a reduced risk in atherosclerotic heart disease. Unfortunately, alcohol can lead to hypoglycemia when ingested on an empty stomach in those patients taking diabetic pharmaceuticals. Alcohol may also induce or worsen hypertension (Fieback et. al., 2007).

Exercise presents unique challenges to individuals with DM. It is crucial to educate diabetic patients on the topic of exercise. Vigorous exercise greatly increases fuel consumption. Since the diabetic population lacks glucoregulatory mechanisms, exercise prevents associated risks, such as exercise induced hypo- or hyperglycemia. Exercise goals include the following: weight reduction/management, decrease in IR, and maintenance of normoglycemia.

One should bear in mind, however, that diabetics with existing problems such as foot ulcers, must avoid aggravating exercise. In individuals with DM and cardiovascular disease, extra caution during exercise is essential. Stress electrocardiogram may be indicative to assess safety (Fieback et. al., 2007). To exercise safely and effectively, the DM population should practice the aforementioned recommendations.

Finally, it is imperative to educate, encourage, and prescribe tailored exercise guidelines. The nurse practitioner (NP) and other healthcare providers are obligated to motivate behavior change. In the United States, leading causes of death are most often due to chronic disease, such as DM. Many chronic diseases are related to health behavior (Duran, 2003). Health promotion and motivating behavior change is fundamental to NP practice. For example, Conlon reports diabetes NPs demonstrate clinical expertise in practice. In fact, Conlon found care managed by diabetes NPs led to a greater decrease in A1C compared to care managed by physician colleagues. NP outcomes led to greater metabolic control, decreasing DM related costs. DM education was also initiated, documented, and offered more consistently by NPs compared to physicians (2010). In conclusion, education and motivation empowers patients to improve health and wellness. NPs and other providers who prescribe tailored exercise guidelines can improve quality of life to the diabetic population by improving glucose control.

Online references

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   http://www.med.umn.edu/cdr/ and http://www.mmf.umn.edu/diabetes/did/index.cfm
   - "The vision of the Center for Diabetes Research is to improve the life of all people with diabetes through world-class investigation performed at the University of Minnesota into the prevention, cure, and management of diabetes and its complications."
   - Limited information on website but donation information available
   - **Number ONE resource, actively participating in research for the development of a CURE:** At the University of Minnesota's world-renowned Schulze Diabetes Institute, leading scientists are working to cure type 1 DM, with the following promising endeavors: human islet-cell transplantation, pig islet transplantation, and stem cell-derived islet cells.
2. Mayo Clinic
   http://www.mayoclinic.com/health/diabetes/DS01121
   - Credible source which clearly identifies key elements such as risk factors, diagnostic criteria, signs of symptoms, treatment, and prevention
   - Highly navigable
3. American Diabetes Association (ADA)
   http://www.diabetes.org/
   - Wide array of resources such as: promoting healthy food and fitness, 1-800-DIABETES information phone line, and association funded research

- Reported financial relationships between panel members and pharmaceutical companies
- Information focuses on the management of DM, rather than finding a cure

4. Center for Disease Control and Prevention (CDC)

   http://www.cdc.gov/diabetes/

   - Highly navigable
   - Numerous topics and highlighted features
   - Diabetes public health resource

5. National Diabetes Information Clearinghouse (NDIC)

   http://diabetes.niddk.nih.gov/

- Offers easy to read publications
- Spanish language publications
- Lists clinical trials, research reports, studies recruiting patients and clinical practice guidelines

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