Preventing disease through lifestyle changes : how diet and exercise can reduce the risk of developing type 2 diabetes mellitus

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Dedication

Special thanks to my family and friends for all of their support

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Table of Contents

Introduction

Background

Diabetes mellitus or type 2 diabetes is one of the major non-communicable and fastest growing public health problems in the world. This condition develops when the body does not make enough insulin or the body cannot use the insulin it produces. Type 2 diabetes or adult-onset diabetes is most common type of diabetes and usually begins when a person is in his or her mid-50s. It has been estimated that the number of diabetes sufferers in the world will double from the current value of about 190 million to 325 million during the next 25 years (Asif, 2014).

Individuals with type 2 diabetes are at a high risk of developing a range of debilitating complications such as cardiovascular disease, peripheral vascular disease, nephropathy, changes to the retina and blindness that can lead to disability and premature death. It also imposes important medical and economic burdens. Genetic susceptibility and environmental influences seem to be the most important factors responsible for the development of type 2 diabetes. This condition is difficult to treat and expensive to manage, but is not inevitable (Asif, 2014).

Lifestyle change is probably the most important single action to prevent type 2 diabetes mellitus (Nilsen, Bakke, & Gallefoss, 2011). Lifestyle changes including physical activity, health dietary habits and weight loss, have been shown to be effective in the prevention of type 2 diabetes (Korkiakangas et al., 2011). Therefore, in order to prevent this condition, action should be taken regarding modifiable factors that influence its development. Measures such as proper testing, and lifestyle changes including healthy eating, walking, exercise, and other physical activities have beneficial effects on human health and prevention of diabetes (Asif, 2014).

Identification of the problem

Based on the International Diabetes Federation, the prevalence of type 2 diabetes (T2D) in adults is 6.9% and will increase to 17% by 2030. A prospective study of 10,920 men and 8,227 women showed that an overweight adult is 2.7 times more likely to develop T2D and that risk increases to 7.2 after 30 years. The Diabetes Prevention Program (DPP) the Finnish Diabetes Prevention Study (DPS), and the Da-Qing trial are seen as milestones in the field because of their strong design, large sample size, and long-term follow-up. Together, they have significantly enhanced the knowledge with regard to the impact of lifestyle modifications such as diet and exercise on the incidence of T2D and glycemic control in individuals with prediabetes (Senechal, Slaght, Bharti, & Bouchard, 2014)

Statement of the problem

The prevention of type 2 diabetes is a globally recognized health priority, but there is a lack of rigorous research investigating optimal methods of translating diabetes prevention programs, based on the promotion of a healthy lifestyle, into routine primary care (Gray et al., 2012).

Statement of the purpose

The purpose of this research project is to determine whether lifestyle changes such as diet and exercise are effective at preventing type 2 diabetes.

Research question

Are changes in lifestyle characteristics, such as diet and physical activity, an effective way to reduce the incidence of type 2 diabetes in individuals with impaired glucose regulation?

Scope: Within 10 years

Definitions

Hyperglycemia: an excess of glucose in the bloodstream

Insulin: Insulin is a hormone that is produced by the beta cells of the pancreas. It is essential for the metabolism of carbohydrates, lipids, fats and proteins. It regulates the body's cells and their growth pattern and measures the body's use of the sugar glucose for energy.

Insulin Resistance: is a condition in which the body's cells become resistant to the effects of insulin

Glycosylated hemoglobin (HbA1c): a test that indicates the average level of blood sugar over the past 2 to 3 months.

Impaired Fasting Glucose: a condition in which the fasting blood glucose level is consistently elevated above what is considered normal levels

Impaired glucose tolerance: (IGT) is a pre-diabetic state of hyperglycemia that is associated with insulin resistance and increased risk of cardiovascular pathology. It may precede type 2 diabetes mellitus by many years and is also a risk factor for mortality.

Oral Glucose tolerance: OGTT) measures the body's ability to use the sugar glucose, the body's main source of energy.

Summary

Type 2 diabetes mellitus is the leading cause of premature deaths. If not properly managed, this condition can lead to a number of health issues such as heart disease, stroke, renal

failure, blindness, nerve damage and leg and foot amputation. Minor changes in lifestyle can greatly reduce the risk of developing this condition. Eating a healthy diet, walking, exercise and other physical activities can help to prevent type 2 diabetes mellitus and promote beneficial effects for human health as a whole (Asif, 2014).

The beneficial effect of the dietary pattern on diabetes mellitus and glucose metabolism in general and traditional food pattern is associated with a significant reduction in the risk of developing type 2 diabetes. The composition of diet is one of the best known dietary patterns for its favorable effects on human health that may act beneficially against the development of type 2 diabetes, including reduced oxidative stress and insulin resistance (Asif, 2014).

In past years, scientific research in nutrition and health has focused on the holistic dietary patterns approach instead of evaluation of single foods or nutrients. One of the most studied patterns is the Mediterranean diet. This diet has been related to various health outcomes such as coronary heart disease, hypertension, dyslipidemia, obesity, cognitive impairment and metabolic syndrome and its components. It has also been suggested to have a beneficial effect in the primary prevention of diabetes (Koloverou, Esposito, Giugliano, & Panagiotakos, 2014).

Exercise is considered a protective factor in the prevention of type 2 diabetes (Zheng et al., 2016). Regular physical activity helps the body cells take up glucose and thus lower blood glucose levels. Important benefits of a regular aerobic exercise program include decreased need for insulin, decreased risk of obesity, and decreased risk for heart disease (Asif, 2014).

Leisure-time activity, low, moderate and vigorous intensity activity, and resistance exercise are associated with a 25–40 % reduction in the relative risk of type 2 diabetes. Walking, occupational activity and cardio-respiratory fitness is associated with a 15, 15 and 55 % decrease in the relative risk of type 2 diabetes, respectively (Aune, Norat, Leitzmann, Tonstad, & Vatten,

2015). Yoga offers a promising intervention for decreasing weight-related type 2 diabetes risk factors and potentially increasing psychological well-being. It also was found to be superior to exercise at decreasing the need for oral hypoglycemia medications (McDermott et al., 2014).

In the last decade over 140 novel genetic markers robustly associated with type 2 diabetes (T2D) and related traits have been discovered. These discoveries are the building blocks of personalized medicine which uses patient genetic risk information to guide prevention, diagnosis or treatment. The clinical validity of genetic markers adds only marginal value in predicting the future development of T2D, and has been shown to be independent of family history. Studies have indicated that high genetic risk for a given disorder is associated with improved motivation to adopt a healthier lifestyle. Participants who were willing to obtain T2D genetic testing reported greater knowledge of genetics, high perceived risk of T2D, and high motivation to adopt a healthier lifestyle (Wessel, Gupta, & de Groot, 2016).

The motivation to exercise presumes that pleasure is gained from it. It is important that exercise not be just a strenuous obligation but also includes fun and enjoyment. Success in increasing the amount of one's own exercise was also satisfying. Barriers to exercise include bad weather or season, health problems, work related factors such fatigue, lack of time, stress and occupation, and the lack of interest in exercise (Korkiakangas et al., 2011).

Methodology

Search terms

"Type II Diabetes", "Prevention", "Lifestyle", "Diet", "Exercise" "Genetics"

Databases

PubMed, Google Scholar, Embase, Web of Science

Inclusion and exclusion criteria for articles

The articles used for this project will be published within the last 5-7 years to include the most current research for this topic. This project will include information from meta-analyses, qualitative studies, control trials and literature reviews. There is no restriction to population or location of the studies for this research. Articles will be printed in the English language.

Literature Review

Diet and exercise

Lifestyle characteristics such as physical activity and stress are important factors that influence the development and prognosis of type 2 diabetes. Changes in diet, an increase in physical activities such walking and exercise are the key components in the prevention and management of type 2 diabetes (Chen et al., 2015). The Community Preventative Services Task Force delivers new recommendations for health care systems and community organizations to offer combined diet and physical exercise programs that provide counseling and longitudinal support for individuals at increased risk for type 2 diabetes (Ackermann, 2015).

In the past 20 years, the effect of exercise and diet in the reduction of prevalence and incidence of type 2 diabetes has been observed in the scientific literature (Senechal et al., 2014). Cochrane reviews summarize that exercise combined with diet can decrease the incidence of type 2 diabetes in high risk individuals. According to the International Diabetes Federation, up to 80% of type 2 diabetes is preventable by adopting a healthy diet and increasing physical activity. Studies show that even small weight losses combined with about 30 minutes of activity per day, are in many instances enough to prevent or at least postpone the disease. One kg weight lost is associated with a 16% reduction in diabetes risk (Nilsen et al., 2011).

The Diabetes Prevention Program (DPP) conducted a study where 3,234 overweight individuals were recruited and randomized in to one of three groups: the placebo group, the metformin group, or the lifestyle intervention group. The main goal was to compare the incidence of type 2 diabetes across the three groups with the hypothesis that the lifestyle intervention group would provide a greater reduction in the incidence of type 2 diabetes. After 2.8 years, the lifestyle group had a 58% reduction in the incidence as well as lower fasting

glucose and HbA1c levels compared to the placebo and control groups. The benefit of lifestyle intervention was maintained after 10 years of follow up and the incidence of type 2 diabetes was still 34% lower compared to the placebo group. These results strongly suggest that lifestyle intervention is a cornerstone in the management of prediabetes in booth overweight and obese individuals (Senechal et al., 2014).

The Finnish Diabetes Prevention Study (DPS) included 522 overweight men and women with impaired glucose intolerance (IGT) that were randomized to either a control or a lifestyle group in the Finns. The lifestyle intervention aimed at reducing body weight by a minimum of 5% by decreasing total calories from fat, saturated fat, and increasing fiber, in addition to doing 30 minutes more of physical activity a day. After 3.2 years of the study, the lifestyle group showed a 58% reduction in the incidence of type 2 diabetes compared to the control group and a mean change of 3.6% and 15.3% in fasting glucose and on the 2-hour oral glucose tolerance test (OGTT) respectively. The control group only showed a 0.8% reduction in fasting glucose and 5.4% on the 2-hour OGTT. After 7 years of continued follow up, the reduction in the relative risk for type 2 diabetes was still lower in the lifestyle group compared to the control group (Senechal et al., 2014).

In the Da-Qing study, 577 individuals with IGT were recruited, and of those, 322 were overweight or obese. They were randomized to a control group, diet group, an exercise group or a lifestyle group which combined both diet and exercise. Participants were instructed to increase physical activity by one to two units per day, one unit equaling 30 minutes of light exercise, 20 minutes of moderate intensity exercise, 10 minutes of strenuous exercise and 5 minutes of very strenuous exercise. A total of 30 visits were scheduled for each group: weekly for the first month, monthly for the next 3 months, and once every 3 month thereafter. The diet targeted a

reduction of 0.5-1.0 kg/month by caloric restriction. After 6 years, the value of fasting glucose and the 2-hour OGTT increased in the diet, exercise and control groups, but a smaller increase was observed in the lifestyle group. After 20 years, the results showed a 43% lower incidence of type 2 diabetes in the lifestyle modification group compared to participants of the control group. The fasting glucose and 2-hour OGTT level was significantly lower in the lifestyle modification group compared to the control group (Senechal et al., 2014).

The PULSE (Prevention Using Lifestyle Education) program was a study that focused on self-administered and gender tailored lifestyle invention to achieve improvements in type 2 diabetes risk factors for men at high risk for developing the disease. It was a six month, self-administered multicomponent lifestyle intervention which aimed to assist men achieve moderate weight loss and improvements in glycemic markers through changes in diet and exercise behaviors. The components of the program include SHED-IT (Self-Help, Exercise and Diet Using Internet Technology) weight loss program which include a DVD, a weight loss handbook, a tape measure, a pedometer and a user guide for the web-based version of calorieking, a tool monitoring tool to log calories (Aguiar et al., 2016).

After 6 months, the PULSE Program intervention group demonstrated significant reductions in anthropometric markers, including weight, waist circumference, body fat percentage and visceral fat area. Significant improvements were also observed for glycemic control including HbA1C, insulin, Homeostatic Model of Insulin Resistance (HOMA-IR2) and Quantitative Insulin Sensitivity Check Index (QUICKI). The prevalence of prediabetes was reduced by 30%. The program was successful at achieving improvements in diabetes risk factors and demonstrated that a 6-month self-administered and gender-tailored lifestyle intervention can effective at improving type 2 diabetes risk factors (Aguiar et al., 2016).

A literature review was conducted to systematically review and meta-analyze the evidence on the multi-component lifestyle interventions for type 2 diabetes prevention. The components include diet, aerobic exercise and resistance training. Eight electronic databases including Medline, Embase, SportDiscus, Web of Science, CINAHL, Informit health collection, Cochrane library and Scopus, which were searched up to June 2013. Eligible studies recruited prediabetic adults or individuals at risk of type 2 diabetes, conducted diet and exercise including both aerobic activity and resistance training programs and reported weight and plasma glucose outcomes (Aguiar, Morgan, Collins, Plotnikoff, & Callister, 2014).

Team 1 Family Medicine Health Center Kalesija performed a prospective study that was conducted in three groups of 20 patients each between the ages of 45 and 80 with abnormal glycoregulation and prediabetes. The study did not include patients who already met the diagnostic criteria for the diagnosis of diabetes. Over the course of 6 months, one group was extensively educated on changing lifestyle, which included healthy nutrition and increased physical activity, the second group was treated with 500 mg metformin twice a day, while the control group was advised about diet and physical activities but different from the first two groups. In the beginning of the study all, patients were measured initial levels of blood glucose, HbA1C, BMI, body weight and height and waist sizes. The same measurement were taken at the end of the 6-month trial (Alibasic, Ramic, & Alic, 2013).

At the end of the 6-month trials, results showed that contrast to the control group, the group with changing lifestyles and the group treated with metformin, significantly reduced the initial body weight, BMI, waist size and HbA1C. Changing lifestyle, which included healthy nutrition and increased physical activity led to a significant reduction in initial body weight in 60% of patients, BMI in 65% of the patients, waist size in 60% of the patients and HbA1C in

55% of patients. These results show that lifestyle modification improve glycemic regulation and reduce obesity which can delay the onset or prevent the development of type 2 diabetes. Pharmacological treatment with metformin also reduces the risk but less dramatically. It is assumed that diabetes prevention through education about the benefits of lifestyle changes could also lead to a reduction in atherosclerosis and cardiovascular disease; the main causes of death in those in type 2 diabetes (Alibasic et al., 2013).

The Diabetes Prevention Program (DPP) is the largest diabetes prevention program to date and was conducted in a multiethnic U. S. sample. Three arms of study were used to conduct this research. The groups were organized by the placebo, metformin and intensive lifestyle changes. After an average follow up of 2.8 years, there was a 58% relative reduction in the progression to diabetes in the lifestyle group compared to the control group. Within in the lifestyle group, 50% achieved a goal of more than 7% weight reduction, and 74% maintained at least 150 min of moderately intense activity each week (Hussain, Claussen, Ramachandran, & Williams, 2007).

The results from the Diabetes Prevention Program found that diet and exercise reduced the incidence of diabetes among individuals with elevated fasting glucose levels. Positive results have also been shown in Japan, India, Finland and China. This proves that diabetes prevention programs that enable lifestyle changes have been shown to be the most effective method at preventing and lowering the risk of type 2 diabetes. These interventions also promote additional health benefits and are less costly than drug treatment (Islam et al., 2013).

Project RICE (Reaching Immigrants through Community Empowerment) is an intervention that was designed to test the efficacy of a pilot community health worker program to promote diabetes prevention and healthy lifestyle changes in the Korean population. Individuals

that were eligible to participate were self-identified as Korean, were identified as at risk by an interviewer-administered diabetes risk assessment adapted from the American Diabetes Association, which test "at risk" scores based on family history of diabetes, BMI, and other factors; and were between the ages of 18-75. Study participants completed a baseline survey after consenting to be in the study and follow-up assessments were conducted at 3 and 6 months intervals. Surveys were administered in Korean by a trained interviewer (Islam et al., 2013).

Primary outcomes were measured at baseline, 3months and 6 months and included weight, BMI, hip-to-waist ratio reduction, access to and utilization of care, and knowledge and practice of physical activity and healthful eating. Questions on diabetes knowledge were adapted from the Diabetes Knowledge Test and risk questions from the American Diabetes Association. Questions on food behaviors such as portion control, preparation, buying and planning as well as the intent to engage in and motivators of physical activity, were adapted from measurements of the behavioral objectives of a weight management intervention (Islam et al., 2013).

Overall, Project RICE demonstrated high acceptability and suggested efficacy of an intervention aimed at improving health behaviors to promote diabetes prevention among individuals completing the pilot program. Participants reported positive feedback about the program and the about the community health worker program in regards its linguistically and culturally tailored nature. Positive changes were seen among treatment group participants between baseline and 6 months. Individuals demonstrated a greater knowledge of diabetes, had improved self-efficacy of behaviors to improve their health and showed positive behavior change in terms of diet and exercise. Individuals in the treatment arm also showed lower self-reported health at 6-month follow-up (Islam et al., 2013).

These results are consistent with other diabetes prevention and management pilot studies in Asian minority communities that have shown improvements in diabetes knowledge, diet, physical activity behaviors, and self-efficacy through education workshops and follow-up support. Study findings indicate that the community health worker model is acceptable and helps to promote behavior changes in nutrition and physical activity, which are important components of diabetes prevention (Islam et al., 2013).

There is a rising need among health care professionals and policy makers to focus on prevention of type 2 diabetes. The most beneficial population-based measures are increased physical activity and decreased consumption of energy dense foods. Targeting patients who have impaired glucose tolerance with lifestyle and interventions focused around increasing activity and altering dietary factors has been particularly effective in North American and Finnish populations. The trials that have produced significant results targeted people at high risk for diabetes and had intensive on-going interventions. They were organized and coordinated by people committed to achieving results (Islam et al., 2013).

Dietary benefits

Insulin resistance and progressive dysfunction of pancreatic beta cells are well established fundamental steps in the pathogenesis of type 2 diabetes mellitus. Risk factors for the conversion from an insulin-sensitive state to insulin resistance include obesity, diet, sedentary lifestyle, and genetics. Obesity and weight gain have grown to epidemic proportions in the United States and may be the most potent catalyst to this transformation (Bazzano, Serdula, & Liu, 2005). Moreover, certain dietary factors may also play a role regarding the development of the disease. Example of this are the loss of traditional healthy dietary habits during the last years,

the increased consumption of energy-foods and increased potion sizes, have been associated with the explosive increase of diabetes (Kastorini & Panagiotakos, 2009).

Epidemiological evidence suggests that several dietary patterns are favorably associated with the prevention of type 2 diabetes. A common characteristic of these dietary patterns is their abundant plant food content. Consuming foods such as whole grains, fiber, fruits, vegetables, nuts and monounsaturated fatty acids, magnesium and moderate intake of alcohol reduce the risk of type 2 diabetes (Kastorini & Panagiotakos, 2009).

In a prospective analysis of overall diet and risk of type 2 diabetes in 80,000 US women, a higher Alternative Healthy Eating Index (AHEI) score has been associated with a substantially lower risk of type 2 diabetes during 18 years of follow-up. Women who scored high on the AHEI had a 36% lower risk of developing diabetes, compared to a low score. This "prudent" pattern is characterized by higher intakes of fruits and vegetables, whole grains and poultry. On the other hand, a diet high in red meat, processed meat, saturated fats, sweets and desserts, French fries and refined grains, has been associated with and elevated risk of type 2 diabetes mellitus in women (Kastorini & Panagiotakos, 2009).

In another large prospective study a factor analysis based on data from food-frequency questionnaires identified two major dietary patterns were identified. 42, 500 U.S. male professionals healthcare professionals answers questions from two separate dietary patterns, one labeled "prudent" pattern and the other labeled "western" pattern. The "prudent" pattern is characterized by higher consumption of vegetables, fruit, poultry, and whole grains. The "western" pattern is characterized by higher consumption of red meat, processed meat, French fries, high-fat dairy products, refined grains, and sweets and desserts. During 12 years of follow-up, the "prudent" dietary pattern score has been associated with a modestly lower risk of type 2

diabetes, while the “western” dietary pattern has been associated with 59% increase of the risk for type 2 diabetes, and even risk when combined with low physical activity or obesity (Kastorini & Panagiotakos, 2009).

A 4-year prospective study of 36,787 adults in the Melbourne Collaborative Cohort Study using factor analysis revealed that the factor characterized by a variety of salad and cooked vegetables, was inversely associated with diabetes, while the one characterized by meats and fatty foods was positively associated with the disease. Another cohort study of 4,304 men and women from 30 communities from different part of Finland followed up for 23 years for the incidence of diabetes. Higher intake of green vegetables, fruits and berries, oil, margarine, and poultry were found to be associated with a 28% reduced risk of type 2 diabetes, whereas the higher intake of butter, potatoes and whole milk was associated with 49% increased risk (Kastorini & Panagiotakos, 2009).

The Whitehall II prospective study with 7,731 participants followed for 15 years, showed that compared to the unhealthy dietary pattern, consisting of white bread, processed meat, fries, and full-cream milk, the healthy pattern consisting of fruit, vegetables, whole-meal bread, low-fat dairy and little alcohol consumption was associated with 26% reduced risk of diabetes. The European Prospective Investigation into Cancer Nutrition (EPIC) Potsdam study was a population-based study that consisted of study of 192 cases of incident type 2 diabetes and 382 control subjects. This case-control study characterized a dietary pattern by a high intake of fresh fruit and a low intake of high-caloric soft drinks, beer, red meat, poultry, processed meat, legumes and bread (excluding wholegrain bread), has been associated with a more favorable biomarker profile and substantially reduced incidence of type 2 diabetes (Kastorini & Panagiotakos, 2009).

A cross-sectional study in South Ireland used a cluster analysis where HOMA-IR (Homeostatic Model Assessment of Insulin Resistance) scores were calculated on 1,018 men and women. These scores assess beta cell function and insulin resistance from basal glucose and insulin or C peptide concentrations. Scores were lower in the prudent diet cluster than in the traditional diet cluster in multivariate analysis. The prudent diet cluster was associated with a 47% reduction of the likelihood of developing insulin resistance compared to the traditional Irish diet (Kastorini & Panagiotakos, 2009).

The Framingham Offspring Study examined the cross-sectional relationship between dietary patterns and insulin-resistant phenotypes in 2,875 participants, using cluster analysis, suggest that consumption of a rich diet in fruits, vegetables, whole grains and reduced fat diary protects against insulin-resistant phenotypes while displacing these healthy choices with refined grains, high-fat dairy, sweet baked foods, candy and sugar-sweetened sodas may promote insulin-resistant phenotypes (Kastorini & Panagiotakos, 2009).

A modified version of the validated Insulin Resistance Atherosclerosis Study (IRAS) food frequency questionnaire was used to assess dietary intake in the Diabetes Prevention Program (DPP). The 117 item questionnaire was administered by trained interviewers at baseline and at 1, 5, 6, and 9 years after randomization. Six food groups were developed based on the Food Guide Pyramid and 27 additional food groups were developed by the DPP Nutrition Coding Center. A total of eight foods were evaluated and the nutritional content of food was determined using the DietSys Nutrient Analysis Program and Nutrition Data System (Jaacks et al., 2014).

The DPP lifestyle intervention outlined specific goals for lowering fat gram and calorie intake either eating high fat foods less often, eating smaller portions of high fat foods or by using

fat lowering alternatives. Results show that participants statistically higher fruit intake and lower red meat and sweet intake and maintained a lower total fat, saturated fat and a higher fiber intake up to 9 years later. Lower red meat and sweets were maintained up to 5 years. Changes in nutrient intake were more likely to be sustained over time compared with food groups and behavior, perhaps because the intervention focused on nutrient intake targets (Jaacks et al., 2014).

A diet that might serve the purpose of preventing diabetes should contain abundant fiber from wholegrain foods, vegetables. Maintenance of ideal body weight and the promotion of the so-called prudent diet which particularly plant based and includes lower intake of red meat, meat products, sweets and high dairy and refined grains appears to be the best strategy to decrease diabetes risk. This is especially successful when dietary recommendations take into account individual preferences. These conditions enable long-term adherence and promotes healthier eating habits (Salas-Salvado, Martinez-Gonzalez, Bullo, & Ros, 2011).

Mediterranean diet

In the past years, scientific research in nutrition and health has focused on the holistic dietary approach instead of the evaluation of single foods or nutrients. Based on this holistic approach, many dietary patterns have suggested and some played a role in the prevention and management of various chronic diseases One of the most studied dietary patterns if the Mediterranean Diet (Koloverou et al., 2014). The Mediterranean diet has been used in many studies because many of its components have been related to common chronic diseases. Ecological evidence suggests that such a diet may be beneficial to overall health, and variants of

this diet have improved the prognosis of patients with chronic diseases such as coronary heart disease and diabetes (Khemayanto & Shi, 2014).

The Mediterranean diet is one of the most known dietary patterns for its beneficial effects on human health. It was first described in the 1960s by Ancel Keys, who based his observation of food habits of from populations in the Mediterranean region. The Mediterranean dietary pattern emphasizes a consumption of fat primarily from foods high in monosaturated fatty acids, mainly olive oil, and encourages consumption of fruits, vegetables, tree nuts, legumes, whole grains, fish and poultry in low to moderate amounts, a relatively low consumption of red meat, as well as moderate consumption of alcohol normally with meals but the proportions of macronutrients vary (Kastorini & Panagiotakos, 2009).

The Mediterranean diet seems to have pleiotropic effects that may act beneficially against the development of type 2 diabetes, including reduced oxidative stress and insulin resistance. High consumptions of vegetables, fruits, legumes, nuts, fish, cereals, and olive oil, together with moderate consumption of alcohol, predominately wine, leads to a high ingestion of dietary fiber, antioxidants, polyphenols, and magnesium. This leads to the belief that the Mediterranean diet could serve as an anti-inflammatory dietary pattern, which could protect from or even treat diseases that are related to chronic inflammation, including type 2 diabetes. In addition, several large studies suggest that the Mediterranean diet prevents weight gain by characterizing a low degree of energy density overall, which exerts a protective effect on the development type 2 diabetes through weight maintenance (Kastorini & Panagiotakos, 2009).

A large prospective study of the 13,380 Spanish university graduates showed that a traditional Mediterranean food pattern rich in olive oil, vegetables, fruits, nuts, cereals, legumes and fish but relatively low meat and dairy products, was associated with an 83% reduction in the

risk of developing type 2 diabetes. There were several participants with a high prevalence of important diabetic risk factors such as older age, high BMI, family history of diabetes, history of hypertension and a higher proportion of former smokers. These high risk participants with better adherence to diet had a lower risk of diabetes, suggesting that the Mediterranean diet might have substantial potential for prevention (Kastorini & Panagiotakos, 2009).

According to a multicenter randomized primary prevention trial, subjects without diabetes allocated to a Mediterranean diet either focused on olive oil or nuts had lower fasting glucose levels and insulin resistance compared to those assigned to a low fat diet. An inverse association was found between the adherence to the Mediterranean diet and indices of glucose homeostasis in a Greek adult population. The higher the adhesion to the diet, the lower the insulin resistance, indicating that one of the mechanisms by which the Mediterranean diet can prevent type 2 diabetes is through the amelioration of insulin sensitivity (Kastorini & Panagiotakos, 2009).

A randomized control trial by Salvado at el in 3, 541 patients at a high cardiovascular risk showed that the Mediterranean diet group had 30% lower rates of diabetes compared to the control group. According to the ATTICA study, greater adherence to the Mediterranean diet was related with lower odds of having diabetes. A cross-sectional study in Cyprus showed that long-term adoption of the Mediterranean diet was associated with reduced odds of having hypercholesterolemia by 9%, hypertension by 6%, and diabetes by 6%, and obesity in the elderly by 12% (Khemayanto & Shi, 2014).

The characteristics of most dietary patterns associated with the prevention of type 2 diabetes are the consumption of large amounts of vegetables, fruits, legumes, whole grains, fish and low fat dairy products. High fiber intake prevents obesity, because of its effects on

improving satiety and weight loss. The Mediterranean diet is a plant-based diet that contains large amounts of fibers, including both soluble and insoluble fibers. Dietary fibers may help to regulate body weight through intrinsic effects and hormonal responses Nuts are part of the Mediterranean diet. They contain protein and fibers which are essential factors in improving satiety. An experimental study by St-Onge et al. reported that incorporating nuts in a regular diet does not lead to weight gain, despite an increase in energy intake (Khemayanto & Shi, 2014).

A three arm randomized trial by Salvado et al. in 418 non-diabetic volunteers showed reduction in incidence of diabetes by 51% in the Mediterranean diet group supplemented with olive oil and 52% in the Mediterranean diet group supplemented with mixed nuts compared with the control group. According to a prospective nurse's health cohort studies involving 83, 818 women, nuts consumption was inversely related with the risk of type 2 diabetes after adjustment for age, BMI, family history of diabetes, physical activity, smoking, alcohol and total energy intake. Despite its high energy density contents, regular consumption of nuts over long terms is beneficial for the prevention of obesity and type 2 diabetes (Khemayanto & Shi, 2014).

Daily moderate intake of alcohol in the form of red wine is one of the characteristics of the Mediterranean diet and is associated with a 30% reduction of the risk of type 2 diabetes in both genders. Moderate alcohol consumption (40 g/day) for 17 days enhanced insulin sensitivity and plasma adiponectin levels, without any changes in the plasma tumor necrosis factor α (TNF α). Adiponectin stimulated glucose utilization and fatty acid oxidation. Adherence to the Mediterranean diet was associated with high levels of adiponectin because of moderate consumption of red wine, which is inversely related to diabetes (Khemayanto & Shi, 2014).

A recent prospective cohort study of Norwegian women showed consumption of 75-100g of lean fish per day, approximately 2.5-3 large servings per week was associated with a reduced

risk of type 2 diabetes by 30 %, compared to zero consumption. According to some cohort studies, low-dietary intake may lower the risk of type 2 diabetes. Consumptions of dairy products has been related to lower dyslipidemia, insulin resistance, blood pressure, and abdominal obesity. Dairy fat improves glucose tolerance, possible through a mechanism involving improved hepatic and systemic insulin sensitivity and reduced liver fat (Khemayanto & Shi, 2014).

Large epidemiologic studies in adults indicate that lower dietary magnesium and lower serum magnesium are associated with increased risk of type 2 diabetes. Evidence from studies have shown low serum and intracellular magnesium concentrations are associated with insulin resistance, impaired glucose tolerance, and decreased insulin secretion. Magnesium is an important factor enzymes involved in carbohydrate metabolism. An intracellular enzyme called tyrosine kinase requires magnesium to allow insulin to exert its blood sugar lowering effects. Components of the Mediterranean diet, such as vegetables, legumes, and nuts are magnesium rich foods. Great adherence of the Mediterranean diet has been associated with high intake of magnesium (Khemayanto & Shi, 2014).

Generally, epidemiological studies reported that dietary content of saturated fat is directly associated with increased risk of type 2 diabetes. On the other hand unsaturated fat is inversely associated with the incidence of type 2 diabetes. A 5-year control study of animal models found that TFA (trans-fatty acids) cause insulin resistance and impaired glucose metabolism. Impaired insulin sensitivity is a main risk factor for type 2 diabetes. The results from the KANWU involving 162 healthy participants recruited from five different countries showed that substitution of SFA (saturated fatty acids) with MUFA (monounsaturated fatty acids) increased insulin sensitivity. High intake of MUFA in the form of olive oil is the main characteristic of the Mediterranean diet. Based on study of Mediterranean country subjects, high dietary MUFA

intake in the form of olive oil has shown significant reduction in the risk of insulin resistance because of the higher oleic acid composition in it (Khemayanto & Shi, 2014).

Some studies have proven that frequent consumption of vegetables and or fruits reduced the risk of type 2 diabetes. The Mediterranean dietary pattern is characterized by a large consumption of antioxidant and vitamin-rich foods, such as fruits, vegetables, olive oil and red wine. Vitamins E and C are associated with reduced risk of the development of type 2 diabetes because of its potent antioxidant property. The intakes of total vitamin E, α-tocopherol, γ-tocopherol, β-tocotrienol, and β-cryptoxanthin were associated with a reduced risk of type 2 diabetes. A prospective cohort 12-year follow-study of higher plasma vitamin C was related to decreased risk of diabetes. Concentration of plasma vitamin C in men and women with diabetes was lower than in those without diabetes (Khemayanto & Shi, 2014).

The Mediterranean diet was meta-analyzed with the DASH diet as and it was concluded that these two diets along with several other diets were equally and consistently associated with a 20% reduction in risk of future type 2 diabetes. In general, these results are in line with current knowledge that health lifestyles are associated with better health. Although diets associated with prevention of type 2 diabetes may vary in their consumption, nonetheless they shared several common components, including whole grains, fruit, vegetables, nuts, legumes, healthy oils, protein sources such as white meat and seafood, little or moderate alcohol and reduced intake of red and processed meats and sugar sweetened beverages. The synergistic effect of these individual components may give healthy diets their numerous beneficial properties in reducing the incidence of type 2 diabetes. The variety of eating patterns associated with diabetes prevention may allow to consider personal preferences such as, tradition, culture, religion, health

benefits, goals and economics, when recommending one diet over the other (Esposito et al., 2014).

Lifestyle factors, such as dietary habits, play a significant role not only against the development of diabetes, but also obesity, one of the main risk factors for the development of the disease and are cost effective in reducing the risk of type 2 diabetes over the long term. Therefore, emphasis must be given on promoting a healthier lifestyle and for finding solutions in order to increase adherence and compliance to these healthy dietary patterns in order to prevent the development of type 2 diabetes. Moreover adherence to s healthy dietary pattern like the Mediterranean diet seems beneficial regarding the development of diabetes (Kastorini & Panagiotakos, 2009).

Benefits of exercise

Obesity is the most important independent modifiable predictor of type 2 diabetes. The major role of physical activity in the modulation of diabetes risk is through the prevention of obesity. The American College of Sports Medicine, The American Heart Association, The American Diabetes Association and the UK Chief Medical Officer all recommend that adults participate in at least 150 minutes of moderate-intensity physical activity or 60 to 90 minutes of vigorous physical activity per week to reduce the risk of type 2 diabetes and cardiovascular disease. The efficacy of physical activity in modulating diabetes risk could be conceivably influenced by factors that influence risk of disease such as family history, sex, ethnicity, obesity status and the degree of glucose tolerance/insulin resistance. The protective effect of physical activity in reducing the risk of diabetes may be greater in the obese or those at increased risk for diabetes (Gill & Cooper, 2008).

There is substantial evidence that type 2 diabetes mellitus can be prevented in high-risk individuals by a lifestyle program of regular exercise and weight reduction (Ades, 2015). Data from 20 longitudinal cohort studies present a consistent picture indicating that regular physical activity substantially reduces risk of type 2 diabetes. The data indicate that protection from diabetes can be conferred by a range of activities of moderate or vigorous intensity and that regular light-intensity activity may also be sufficient. The risk reduction associated with increased risk physical activity appears to be the greatest in those at increased baseline risk of the disease such as the obese, those with a positive family history and those with impaired glucose regulation. Data from six large scale diabetes prevention trials in adults with impaired glucose or at high risk of cardiovascular disease indicate that increasing moderate physical activity by approximately 150 minutes per week reduces the risk or progression to diabetes, with the effect being greater if accompanied by weight loss(Gill & Cooper, 2008) .

In the Diabetes Prevention Program, a lifestyle program of at least 150 minutes per week of physical activity and a behavioral weight loss program aiming to reduce body weight by 7% was applied to overweight, glucose intolerance individuals at high risk for the development of type 2 diabetes. Compared with placebo, over a follow up period of 2.8 years, the lifestyle intervention reduced incidence of type 2 diabetes by 58% (Ades, 2015).

In University of Pennsylvania alumni, the protective effect of physical activity was strongest in men at highest risk of diabetes, defined as those with a high BMI (body mass index), a history of hypertension, or the offspring of diabetic parents. Similarly in the Kuopio Ischaemic Heart Diabetes Risk Factor study, participation in at least 40 minutes of physical activity per week at greater than or equal to 5.5 MET elicited a 3.5-fold greater reduction in risk of type 2 diabetes compared with men at low diabetes risk. In the Physicians' Health Study, participation

in vigorous physical activity reduced the risk of type 2 diabetes to the greatest extent in men with high BMI (Gill & Cooper, 2008)

In women, both light/moderate and vigorous physical activity has been shown to confer lower risk of type 2 diabetes. In the Nurses' Health study, undertaking at least one bout of vigorous exercise per week conferred an approximately 33% reduction in risk in women, compared with no weekly exercise, with further exercise bouts providing no additional benefit. In the Iowa Women's Health Study, women who reported no vigorous activity but who were active more than four times per week had a 43% lower diabetes risk than those who rarely exercised. Women who walked for at least one hour per week had significantly lower risk than those who did not. Women who walked at least 7 hours per week had no greater risk reduction than those walking at least 4 hours per week. Women who met the physical activity guideline of at least 1000 kcal/ week also had a lower risk of diabetes. This data strongly support the utility of either light/ moderate or vigorous activity in the prevention of diabetes in women (Gill & Cooper, 2008).

In men, vigorous activity is associated with a 40-50% reduction in risk of diabetes. Moderate physical activity and energy expenditure in physical activity are also associated with reduced risk of diabetes in men. Studies involving both men and women showed similar associations to single-sex studies, proving that physical activity is significantly associated with reduced risk of type 2 diabetes. Longitudinal cohort studies present a consistent picture of the protective effect of physical activity for the development of type 2 diabetes. Regular physical activity conferred a reduction in risk of 20-30% after adjustment for confounding factors including age, health status including family history of diabetes and presence of other risk factors

and BMI. Protection against the risk for type 2 diabetes can be conferred by a range of activities of moderate or vigorous, regular or light intensity (Gill & Cooper, 2008).

Beneficial exercise methods

The benefit of aerobic physical activity for preventing type 2 diabetes is well established. Regular engagement in aerobic activities such as jogging, running, and brisk walking are associated with substantially lower risk of type 2 diabetes. In a recent epidemiologic study, weight training was associated with reduced risk of type 2 diabetes independent of aerobic physical activity in men. Lower intensity muscular conditioning exercises such as yoga are popular physical activities among women (Grontved et al., 2014). Chronic moderate and vigorous aerobic exercise (6-12 months) reduces insulin resistance. However, evidence suggests that the duration of exercise is more important than intensity for eliciting favorable responses to insulin action. Regular training enhances skeletal muscle responsiveness to insulin by increasing activity and/or expression of proteins involved in insulin signaling and glucose metabolism. Aerobic exercise increases skeletal muscles' lipid storage and fat oxidation capacity. This is important because fat oxidation plays a role in improved insulin action (Tudor-Locke & Schuna, 2012).

Epidemiological data from large cohort studies indicate that moderate exercise such as walking, and more vigorous activities protect against the development of type 2 diabetes. A synthesis of results from four cohort studies indicate that brisk walking for at least 150 min/week, when compared to minimal amounts of weekly walking significantly lowers the risk for type 2 diabetes (Tudor-Locke & Schuna, 2012).

High versus low total physical activity, leisure-time activity, low, moderate and vigorous intensity activity, resistance exercise, occupational activity, walking and cardiorespiratory fitness were associated with a statistically significant reduction in the risk of type 2 diabetes. Most of these activities were associated with a 25-40% reduction in the risk of type 2 diabetes, while walking occupational activity and cardiorespiratory fitness were associated with a 15, 15 and 55% decrease in the relative risk of type 2 diabetes, respectively. In addition, subjects who increased their activity levels or those with consistently high levels of over time had a 36 and 41% lower subsequent risk of type 2 diabetes (Aune et al., 2015).

Research is emerging that aerobic physical activity improves pancreatic beta –cell function in prediabetes and diabetes. Physical activity appears to be most beneficial in improving bets-cell function for those who have some residual beta-call function. A recent study conducted using Zucker diabetic fatty rats show that 30 minutes of swimming 5 days per week prevented type 2 diabetes by increasing beta-cell mass. It is currently unclear if the improvements in hepatic insulin sensitivity and the maintenance of beta-call function are a direct result of physical activity or if these beneficial adaptations are indirectly brought through improvements in skeletal muscle insulin sensitivity, which improves overall glucose and lipid oxidation (Burr, Rowan, Jamnik, & Riddell, 2010).

Studies suggest that engagement in muscle-strengthening and conditioning activities such as resistance exercise, yoga, stretching and toning, is associated with a lower risk of type 2 diabetes. Engagement in both aerobic moderate and vigorous physical activity and muscle-strengthening type activity is associated with substantial reduction in the risk of middle age and older women. A randomized trial with one-year follow-up comparing restorative yoga vs. stretching among underactive adults at the University of California, San Francisco and San

Diego showed that restorative yoga was marginally better than stretching for improving fasting glucose (Jyotsna, 2014).

Yoga is a mind and body practice based on traditional Indian philosophy, often incorporating three major components: held or sequences of physical postures, breathing exercises and meditation. Yoga's energy expenditure is similar to other low to moderate exercise and recent review found yoga had beneficial outcomes similar to those of moderate exercise in populations with type 2 diabetes mellitus. In Nagarathna et al., authors found that yoga was superior to exercise at decreasing the need for oral hypoglycemia medications, decreasing low-density lipoproteins and increasing HDL, suggesting a benefit associated with yoga in addition to that of just increasing exercise (McDermott et al., 2014).

It has been concluded that yoga offers a promising lifestyle intervention for decreasing weight related type 2 diabetes risk factors and potentially increasing psychological well-being. Studies indicate that a yoga program would be a possible risk reduction option for adults at high risk for type 2 diabetes In addition, yoga holds promise as an approach to reducing cardiometabolic risk factors and increasing exercise self-efficacy for this group. It has been useful in geriatric type 2 diabetes where vigorous exercise may not be acceptable. Yoga is being tried for it benefits not only in India where it is traditionally familiar but also in the US, UK, and Australia (Jyotsna, 2014).

Lifestyle interventions including exercise have been effective in offsetting type 2 diabetes complications and the progression from prediabetes of metabolic to type 2 diabetes mellitus. By modifying muscle fibers and enhancing beta cell functions, exercise can optimize insulin sensitivity and improve glucose intolerance. Thus, exercise may be particularly effective in

earlier disease stages and has been associated with a 30% reduction in metabolic syndrome and a type 2 diabetes risk reduction of 63-65% in people with prediabetes (McDermott et al., 2014).

Genetic factors

The development of type 2 diabetes may result from a complex interaction between genetic and environmental factors. This high incidence of type 2 diabetes in certain populations and among first-degrees relatives of those with medical condition as well as the high concordance in identical twins provides strong evidence that genetic factors underlie susceptibility to type 2 diabetes. The common form of type 2 diabetes mellitus is genetically heterogeneous and almost certainly polygenic. Moreover, strong gene/gene and gene/environmental interactions play important roles in the development of type 2 diabetes. Therefore, to identify genes for type 2 diabetes in post-era, a thorough understanding of how risk alleles interact with each other (gene-to-gene interaction) and with the environmental risk factors (gene-to-environmental interaction) as well as identification of many more risk alleles are required (Park, 2004).

In the last decade over 140 novel genetic markers robustly associated with type 2 diabetes and related traits have been discovered. These discoveries are the building blocks of personalized medicine-using patient genetic risk information to guide, prevention, diagnosis or treatment. The clinical validity of genetic markers adds only marginal value in predicting future development of type 2 diabetes and has been shown to be independent of family history. Studies have indicated high genetic risk for a given disorder is associated with improved motivation to adopt a healthier lifestyle. Participants who were specific to type 2 diabetes reported greater knowledge of

genetics, high perceived risk, and higher motivation to adopt a healthier lifestyle were positively correlated with willingness to obtain type 2 diabetes genetic testing (Wessel et al., 2016).

In previous studies, several candidate genes have been tested. Of the genes encoding for two subunits of the ATP-sensitive potassium channels in pancreatic B-cells (SUR1 and Kir6.2 genes) the Finnish DPS showed that a haplotype in the SUR1 gene was associated with risk for conversion to type 2 diabetes in the control group, but not in group receiving an intensive exercise and diet intervention, indicating potential benefits for exercise in subjects at high risk of diabetes. Allelic variations in the VDR (vitamin D receptor) gene have been associated with body weight, glucose homeostasis, diabetes and its vascular complications. Men homozygous for the B allele of the Bsml VDR gene polymorphism had higher fasting glucose levels than B carriers in those with low physical activity (less than or equal to 3 h per week), but not in those with high physical activity (Hu, Rico-Sanz, Lakka, & Tuomilehto, 2006).

PPAR-gamma2 (peroxisome proliferator-activated receptor gamma 2) gene is a transcription factor that regulates adipocyte differentiation, fat-specific gene expression and insulin action, and is a major candidate gene for type 2 diabetes. The interaction of the Pro12Ala gene variant and physical activity has been examined in a number of studies. In a study in patients with diabetes, the alanine carrier has a larger decrease in fasting plasma glucose after endurance or resistance exercise training. In individuals with impaired glucose tolerance of the Finnish DPS, Ala homozygotes lost more weight compared to the Pro 12 carriers after a lifestyle intervention and none of the Ala12 homozygotes developed diabetes. In offspring of patients with type 2 diabetes, body weight decreased more in the Ala12 allele carriers than in the Pro12 homozygotes after a ten week training program. In healthy Japanese men the alanine allele was associated with improvement in insulin resistance after exercise training (Hu et al., 2006).

The Arg 64 allele of the Trp64 Arg polymorphism of the beta-ADR gene has been associated with an earlier onset of type 2 diabetes. In the Finnish DPS, people in the lifestyle intervention group who possessed the Arg 64 allele in the beta3-ADR gene tended to have a higher incidence of type 2 diabetes. The elevation of plasma NEFAs (non-esterified fatty acids) during lipolysis is associated with insulin resistance and the development of type 2 diabetes. In non-diabetic people physical activity modified the effect of the Arg16Arg genotype of the B2-ADR gene on the suppression NEFA levels after an oral glucose load (Hu et al., 2006).

The ACE (angiotensin I-converting enzyme) gene catalyses the conversion of angiotensin I to angiotensin II. In hypertensive individuals with an average age of 63 years old, an aerobic exercise program resulted in greater increase in insulin sensitivity and a decrease in acute insulin response to glucose in the I/I homozygotes of the insertion/deletion polymorphism in intron 16 of the ACE gene. In sedentary individuals, carriers of the I allele has a trend for a greater reduction in insulin response to an oral glucose tolerance test after a strength training program. It has been proposed that the ACE genotype might modify the potential to become physically active and to achieve higher physical fitness (Hu et al., 2006).

A promoter region Gly174Cys polymorphism in the IL-6 (interleukin-6) gene has been associated with the risk of type 2 diabetes. In sedentary men and postmenopausal women, the Gly174Cys polymorphism modified the training induced changes in glucose levels. A significant decrease after six months of aerobic exercise training occurred only in individuals with the GC genotype. A promoter region Gly308Ala polymorphism in the TNF-alpha (tumor necrosis factor-alpha) gene has been shown to have an effect on TNF-alpha transcription and plasma levels by which it may affect insulin signaling and secretion. Among individuals with glucose intolerance

in the Finnish DPS, those with the A308 had higher conversion to type 2 diabetes in the exercise and diet intervention group (Hu et al., 2006).

The HL (hepatic lipase) gene regulates lipoprotein metabolism, and the Gly250Ala polymorphism in the promoter region of the HL gene has been associated with insulin resistance. Exercise-induced improvement in insulin sensitivity was greater in the CC homozygotes in sedentary Caucasians and African Americans. In the Finnish DPS, the proportion of people with the GG genotype of the Gly250Ala polymorphism, who converted to diabetes in the exercise and diet intervention group was higher than the proportion of individuals with the A250 allele (Hu et al., 2006).

Health benefits regarding diabetes prevention from physical activity may vary, depending on the genotype (Hu et al., 2006). Through direct-to-consumer venues, genetic susceptibility testing for polygenic disorders such as type 2 diabetes have become available to the public. Genetic susceptibility testing offers personalized and detailed risk information, which can also provide an opportunity to inform the public about the development and prevention of type 2 diabetes (Wessel et al., 2016). Susceptibility genes and gene to environmental interactions can help identify people who can get more benefit from prevention and can also provide better and personalized preventive measure based on genetic information (Park, 2004).

Benefits and barriers of lifestyle change

Interventions to promote changes in diet and/ or physical activity in adults with an increased risk of type 2 diabetes are more likely to be effective if they target both of these lifestyle factors, involve the planned use of established behavior change techniques and have a clear plan for supporting maintenance of behavior change. Current guidelines for physical

activity based on leading public health agencies including the ADA, recommend at least 150 minutes per week of moderate to vigorous aerobic-based exercise to prevent and treat chronic metabolic diseases. There is a robust dose-response relationship between the amount of exercise performed and all-cause mortality and cardiovascular disease mortality in middle-aged and elderly populations. Despite the overwhelming proof that an inactive lifestyle leads to a host of chronic diseases and premature death, the majority of adults fail to meet the minimum physical activity guidelines (Hawley & Gibala, 2012).

Barriers to physical exercise include bad weather or season, health problems, especially those involving chronic illnesses and pain in the back or knees, work-related factors, fatigue, lack of time, stress and occupation, and lack of interest in exercising (Korkiakangas et al., 2011). The most commonly cited barrier to performing regular exercise, regardless of sex, age, ethnicity or health status is lack of time. In addition, adherence to exercise programs that compromise continuous bouts of prolonged exercise is poor unless there is an adequate level of supervision and appropriate infrastructure (Hawley & Gibala, 2012). Work-related factors such as stress, the amount of work and one's capability to manage these are important to highlight because these may also explain the lack of time to exercise (Korkiakangas et al., 2011).

Exercise motivation has an important role in long-term weight management and intrinsic sources of motivation are most important when adhering to an exercise method. According to a review of qualitative studies by Allender et al., enjoyment weight management and social relationships/interactions are common reasons for participation in physical activity. Social relationships related to exercise and encouragements from others were exercise motivators in this study and in a previous work by Jones et al. (Korkiakangas et al., 2011).

The motivation to exercise presumes that pleasure and enjoyment is gained from it. It was important that exercise was not just a strenuous obligation but also fun and provided a sense of overall well-being. Success in increasing the amount of one's exercise was also satisfying. Pleasure from exercise sprung from factors that make the experience interesting. Encouragement and social support from others was seen as important and meant different things to different people. Factors of importance included common decisions, exercising together or acceptance of the person's exercise habits. When exercising together with a family member or a friend, it was important that the person was of the same physical level. Exercising together made it easier to get off the couch and start moving. The wish to become one of the people with an active lifestyle, good memories of exercise in the past, admiration of active friends, or the desire to be a good role model for one's children also motivated subjects to exercise (Korkiakangas et al., 2011).

Technical equipment such as pedometers and heart rate monitors and an exercise diary, was also considered motivational. The use of a pedometer has been found to increase physical activity among persons with high risk of type 2 diabetes in target group of study "The Effectiveness and Feasibility of Activating Counseling Methods and Videoconferences in the Dietary Group Counseling" the pedometer was also one of the motivators of exercise. Consistent self-monitoring of exercise through daily entries in the physical activity was associated with fewer difficulties with exercise, a greater amount of exercise and weight loss. The pedometer is a useful tool observing and for elevating own level of exercise and also helps to set goals for exercising (Korkiakangas et al., 2011).

According to studies, the most common barriers for regular exercise were poor state of health, overweight, lack of time, unwillingness to exercise and lack of exercise facilities. Regular

exercise, daily physical activity, and exercise as a habit and a lifestyle were exercise motivators. Success in increasing exercise, encouragement and support, and the perspective of being a role model were also motivating. Improving metabolic health and reducing the risk of developing type 2 diabetes can be achieved by promoting a positive attitude, seeking solutions for barriers and highlighting motivating factors. It is also important to notice the factors related to life situations and work and family influence on physical activity. Special solutions by different occupations at different workplaces might be needed to promote exercise among workers with a high risk of type 2 diabetes. The results can also be useful when developing counseling methods because they provide concrete content for counseling discussions between persons and professionals at high risk for type 2 diabetes (Korkiakangas et al., 2011).

Discussion

The purpose of this research was to determine whether lifestyle changes such as diet and exercise are effective at reducing the incidence of type 2 diabetes. Several research studies have proven that lifestyle modifications such as diet and exercise have a beneficial effect on reducing the incidence of type 2 diabetes. Adopting a healthy diet and increasing physical activity has been proven to postpone and essentially prevent the onset of this condition. Dietary regimes that are high in fiber and dairy with reduced intake of red meat, meat products and sweets have been a successful strategy against acquiring type 2 diabetes independent of exercise. The Mediterranean diet encompasses components that are effective against insulin resistance and oxidative stress, further inhibiting the progression on this condition. Increasing physical activity to approximately 150 minutes per week reduces the risk and progression of this disease. Aerobic activities such as brisk walking, jogging, and running as well as less intensive activities such yoga have proven to reduce the risk of developing type 2 diabetes. Genetic testing has helped to raise awareness about the potential risk of developing type 2 diabetes, which has been effective at producing lifestyle change. Despite common barriers such as variation in weather, health conditions, stress, occupational demands, lack of interest and lack of time, motivating factors have been a way to produce effective lifestyle modifications to reduce the risk and onset of type 2 diabetes.

Discussion

Based on the literature, studies have shown that adopting a healthy diet and increasing physical activity can prevent the onset of type 2 diabetes. The International Diabetes Federation showed that and 80% reduction in the onset of type 2 diabetes occurred with diet modification

and that even small weight losses combined with about 30 minutes of activity per day, are in many instances enough to prevent or at least postpone the disease. One kg weight lost is associated with a 16% reduction in diabetes risk. The Diabetes Prevention Program proved that lifestyle intervention provides a greater reduction in the incidence of type 2 diabetes compared to the placebo and control group. Lifestyle changes also lowered fasting glucose and HbA1C levels that were maintained after a 10-year follow, which strongly suggests that lifestyle intervention is a cornerstone in the management of prediabetes. The Finnish Diabetes Prevention Study (DPS) and the Da-Qing study proved that decreasing total calories from fat, saturated fat, and increasing fiber, in addition to doing at least 30 minutes more of physical activity a day has a major impact on lower fasting glucose levels and 2 hour OGTT.

Epidemiological evidence suggests that several dietary patterns are favorably associated with the prevention of type 2 diabetes. These patterns suggest consuming foods such as whole grains, fiber, fruits, vegetables, nuts and monounsaturated fatty acids, magnesium and moderate intake of alcohol. The Melbourne Collaborative Cohort Study using factor analysis revealed that the factor characterized by a variety of salad and cooked vegetables, was inversely associated with diabetes, while the one characterized by meats and fatty foods was positively associated with the disease. The Whitehall II prospective study with showed that compared to the unhealthy dietary pattern, consisting of white bread, processed meat, fries, and full-cream milk: the healthy pattern consisting of fruit, vegetables, whole-meal bread, low-fat dairy and little alcohol consumption was associated with 26% reduced risk of diabetes. The Framingham Offspring Study examined the cross-sectional relationship between dietary patterns and insulin-resistant phenotypes suggest that consumption of a rich diet in fruits, vegetables, whole grains and reduced fat diary protects against insulin-resistance while a diet consisting of refined grains,

high-fat dairy, sweet baked foods, candy and sugar-sweetened sodas may promote insulin-resistance.

The Mediterranean diet has been used in many studies because many of its components have been related to common chronic diseases. This dietary pattern emphasizes a consumption of fat primarily from foods high in monounsaturated fatty acids, mainly olive oil, and encourages consumption of fruits, vegetables, tree nuts, legumes, whole grains, fish and poultry in low to moderate amounts, a relatively low consumption of red meat, as well as moderate consumption of alcohol. Cohort and meta-analysis studies demonstrate that the Mediterranean diet seems to have pleiotropic effects that may act beneficially against the development of type 2 diabetes, including reduced oxidative stress and insulin resistance. This leads to the belief that the Mediterranean diet could serve as an anti-inflammatory dietary pattern, which could protect from or even treat diseases that are related to chronic inflammation, including type 2 diabetes.

In addition, several large studies suggest that the Mediterranean diet prevents weight gain by characterizing a low degree of energy density overall, which exerts a protective effect on the development type 2 diabetes through weight maintenance. The Mediterranean diet was meta-analyzed with the DASH diet as and it was concluded that these two diets along with several other diets were equally and consistently associated with a 20% reduction in risk of future type 2 diabetes. In general, these results are in line with current knowledge that health lifestyles are associated with better health.

The major role of physical activity in the modulation of diabetes risk is through the prevention of obesity. The efficacy of physical activity could be conceivably influenced by factors that influence risk of disease such as family history, sex, ethnicity, obesity status and the degree of glucose tolerance/insulin resistance. The protective effect of physical activity in

reducing the risk of diabetes may be greater in the obese or those at increased risk for diabetes. Data from 20 longitudinal cohort studies indicate that protection from diabetes can be conferred by a range of activities from light, regular, moderate or vigorous intensity.

Regular engagement in aerobic activities such as jogging, running, and brisk walking are associated with substantially lower risk of type 2 diabetes. Weight training is associated with reduced risk of type 2 diabetes independent of aerobic physical activity in and showed to be more favorable among men. Lower intensity muscular conditioning exercises such as yoga are popular physical activities among women. Chronic moderate and vigorous aerobic exercise (6-12 months) reduces insulin resistance. Consistent training enhances skeletal muscle responsiveness to insulin by increasing activity and/or expression of proteins involved in insulin signaling and glucose metabolism.

Aerobic exercise increase skeletal muscles' lipid storage and fat oxidation capacity which is important factor that plays a role in improved insulin action. Physical activity appears to be most beneficial in improving bets-cell function especially in those with some residual function. A recent study conducted using Zucker diabetic fatty rats show that 30 minutes of swimming 5 days per week prevented type 2 diabetes by increasing beta-cell mass. Recent studies show that yoga is superior to exercise at decreasing the need for oral hypoglycemia medications, decreasing low-density lipoproteins and increasing HDL.

The development of type 2 diabetes may result from a complex interaction between genetic and environmental factors. Studies have indicated high genetic risk for a given disorder is associated with improved motivation to adopt a healthier lifestyle. Participants who were specific to type 2 diabetes reported greater knowledge of genetics, high perceived risk, and higher motivation to adopt a healthier lifestyle were positively correlated with willingness to

obtain type 2 diabetes genetic testing. Susceptibility genes and gene to environmental interactions can help identify people who can get more benefit from prevention and can also provide better and personalized preventive measure based on genetic information.

Barriers to physical exercise include bad weather or season, health problems, especially those involving chronic illnesses and pain in the back or knees, work-related factors, fatigue, lack of time, stress and occupation, and lack of interest in exercising. The most commonly cited barrier to performing regular exercise, is lack of time. The motivation to exercise presumes that pleasure and enjoyment is gained from it. Research studies suggest that it is important that exercise not be a strenuous obligation but also fun and provided a sense of overall well-being. Pleasure from exercise sprung from factors that make the experience interesting and success in increasing amounts was also satisfying.

Encouragement and social support from others was seen as important including common decisions such as exercising together or acceptance of the person's exercise habits. When exercising together with a family member or a friend, it was important that the person was of the same physical level. Exercising together made it easier to get off the couch and start moving. Technical equipment such as pedometers and heart rate monitors and an exercise diary, was also considered motivational Success in increasing exercise, encouragement and support, and the perspective of being a role model were also motivating. Improving metabolic health and reducing the risk of developing type 2 diabetes can be achieved by promoting a positive attitude, seeking solutions for barriers and highlighting motivating factors.

Limitations

Limitations to this research include not exploring how patient noncompliance effects the overall outcome of lifestyle changes. Health policies and financial status as a factor toward lifestyle change and success was not assessed in this research. Long-term adherence to dietary patterns and how breaking barriers have helped to adopt healthier dietary habits was not thoroughly assessed in this research.

Implications for future research

Future large scale community based trials might be helpful in determining more personalized factors by ethnic group and what variables play a role in the success of lifestyle interventions for the prevention of type 2 diabetes. More long-term follow-up studies would be helpful to assess if lifestyle changes are maintained long-term and how influential continue regimes are at preventing type 2 diabetes. Future research is suggested to assess the barrier of patient noncompliance and how it effects the overall outcomes of type 2 diabetes as well as the key factors that make adherence and compliance successful. The effect of health policy and financial status should be further assessed to determine the impact that these variables have on lifestyle changes. Future research is needed to explore the correlation between genetic testing and reduced incidence of type 2 diabetes along with the possible screening and testing recommendations for patients as risk for disease development.

Relevance to the PA profession

As healthcare providers, it is important to address type 2 diabetes with the intent to prevent the onset of development. Although it is indicated that diet and exercise are the initial

steps of prevention in the pre-diabetic stage, it is important that we find a way to make this work for our patients. It is not enough to just recommend it. We must take an active part in changing the statistics. We need to encourage healthy diet but personalize it toward the patient based on resources and availability. Patients need a better understanding of what foods are considered "healthy" and "unhealthy" and how to portion meals not only to promote weight loss but help to stabilize blood sugars throughout the day. Exercise habits need to be assessed and personalized based on patient interest.

Barriers to diet and exercise should be thoroughly assessed along with ways to make this combined regime successful. Patient education is important. Patients need to understand the nature of this diagnosis and the long term effects that come along with poor and uncontrolled blood sugars. Various exercise regimes should be discussed to broaden the horizons of exercise and break the stereotype that exercise only occurs in a gym or fitness center. Finding an exercise method that works best for each patient will provide the best result. Genetic testing and health care screenings should be offered to patients who are at high risk or interested in knowing the severity of their risk. Goals should be established to work toward at each patient-provider visit to ensure a successful outcome. Patients should leave our clinics and hospitals with an understanding of what this diagnosis means and be motivated to make the necessary lifestyle changes to prevent the onset of this disease.

Recommendations

The World Health Organization estimates that by 2025 as many as 200-300 million people worldwide will have developed type 2 diabetes. The distressing increased incidence in children has raised even more concern. Roughly half of the risk of type 2 diabetes can be

attributed to and environmental exposure and the other half to genetics. Central themes for prevention are risk factors, obesity sedentary lifestyle, certain dietary components and perinatal factors (Hussain et al., 2007).

The Community Preventative Services Task Force delivers new recommendations for health care systems and community organizations to offer combined diet and physical exercise programs that provide counseling and longitudinal support for individuals at increased risk for type 2 diabetes (Ackermann, 2015).

The American Association of Clinical Endocrinologists recommend lifestyle changes as risk stratification for diabetes complications (Rodbard et al., 2009).

The American Diabetes Association suggests that glycosylated hemoglobin (HbA1C) between 5.7% and 6.4% be used to identify individuals with prediabetes (Senechal, 2014). It is recommended that all patients with diabetes to make nutrition therapy as a part of their diabetes treatment plan (Khemayanto, 2014). Dietary strategies include that reducing calories and intake of dietary fat and increasing dietary fiber and foods containing whole grains while limiting the intake of sugar-sweet beverages (Esposito et al., 2014).

The American Diabetic Association recommends eating foods containing carbohydrate from whole-grains, fruits, vegetables, and low-fat milk as a part of a healthy diet for persons with diabetes because these foods are likely to have a low glycemic index. Diabetics should regard the total amount of carbohydrate on meals in meals or snack as more important for blood glucose and regulation the source or type (Bazzano et al., 2005).

The American College of Sports Medicine, The American Heart Association, The American Diabetes Association, The Diabetes Prevention Program and the UK Chief Medical Officer all recommend that adults should participate in at least 150 minutes of moderate-intensity

physical activity or 60 to 90 minutes of vigorous physical activity per week to reduce the risk of type 2 diabetes and cardiovascular disease (Gill & Cooper, 2008).

The typical weight loss recommendation to improve metabolic health, specific to overweight and obese individuals with prediabetes ranges between 5% and 10% of the initial body weight. Most studies including individuals with prediabetes show that lifestyle modification programs using diet and exercise are effective in reaching this recommendation (Senechal, 2014).

The American College of Sports Medicine embraces a "whole message" that advocates that adults should "*walk more, sit less and exercise*" that is relevant to treating prediabetes and preventing type 2 diabetes. Recommendations include taking 7,500 steps or more a day ("Walk more"), avoiding taking less than 5,000 steps per day and limit prolonged sitting bouts ("Sit less") and accumulate 3,000 or more steps a day at 100 or more steps per min ("Exercise") (Tudor-Locke, 2012).

The Centers for Disease Control and Prevention, The American College of Sports Medicine, the National Institute of Health and the World Health Organization have recommended that every adult should have at least 30 minutes of moderate-intensity physical activity (such as brisk walking, cycling, swimming, home repair, and yard work) on most, preferably all, days of the week. At least 30 minutes of moderate-to vigorous physical activity, is effective in preventing type 2 diabetes (Hu, 2006).

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Abstract

Objective: The purpose of this research project is to determine whether lifestyle changes including diet and exercise are effective at preventing type 2 diabetes.

Methods: Search terms include “Type II Diabetes”, “Prevention”, “Lifestyle”, “Diet”, “Exercise”. Databases include PubMed, Google Scholar, Embase, and Web of Science. Articles were published within a 5-7-year time frame to include the most current research. Included information were from meta-analyses, qualitative studies, control trials, and literature reviews. No restriction to population or location for this research. Articles were printed in the English language.

Results: Studies show that adopting a healthy diet and increasing physical activity can prevent the onset of type 2 diabetes. 80% risk reduction can occur with diet modification and 30 minutes of physical activity per day. A 16% reduction risk is associated with one kg of weight loss. Fasting glucose and HbA1C levels were also lowered, strongly suggesting that lifestyle intervention is a cornerstone in the management of prediabetes.

Conclusion: Preventing the onset of type 2 diabetes can be achieved by through lifestyle changes. Adopting healthy dietary regimes and establishing an exercise regime that caters to the preferences and personal lifestyle of each individual has the greatest advantage at reducing the risk of type 2 diabetes.