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# Impact of Physical Activity on Type 2 Diabetes Mellitus

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## Abstract

*Type 2 diabetes mellitus has become an increasingly prevalent worldwide epidemic. The tremendous economic burden, coupled with the numerous secondary risks associated with the disease, have encouraged researchers to search for causes as well as treatment methods. This research paper focuses on the effect of physical activity as a preventative measure for those at risk for diabetes and as a treatment method for those already diagnosed with the disease. The articles collected included meta-analysis, randomized controlled trials, cohort studies, surveys, etc. The studies that were analyzed have indicated an inverse relationship between physical activity and type 2 diabetes. Since there are multiple variables involved, it is challenging to pinpoint the specific level of effect that physical activity has. However, the majority of the research has shown some level of correlation.*

## Introduction

The drastic increase in type 2 diabetes mellitus has caused many to research the risk factors associated with this disease. Type 2 diabetes is characterized by the body resisting the effect of insulin or insufficient insulin production. Insulin is a hormone that regulates blood glucose levels. High blood glucose levels over a prolonged period can cause damage to the eyes, heart, nerves, and kidneys. More than 1.6 million new cases of type 2 diabetes arise in the US each year, and millions more are at high risk. (ADA, 2018) It is rated as the seventh deadliest disease in the world by the World Health Organization (WHO). Furthermore, individuals diagnosed with this disease are 2-4 times more likely to develop secondary complications such as stroke, peripheral vascular, and cardiovascular disease.

The various complications caused by type 2 diabetes have created a severe physical and economic burden on our society. Those suffering from this disease have medical costs around 2.3 times higher than those who do not have diabetes. (ADA, 2015). An estimated \$21.6 billion is spent in New York each year for the treatment of diabetes and prediabetes. It has thus become a priority to identify those who are at a higher risk and provide preventative measures to help decrease the likelihood of acquiring the disease.

The vast research conducted regarding the numerous risk factors contributing to this disease has concluded that type 2 diabetes results from the interaction between a genetic predisposition and behavioral and environmental risk factors (Tuomilehto et al., 2001). Can lifestyle modification, specifically physical activity, prevent or decrease associated diseases/symptoms of type 2 diabetes mellitus.

## Methods

The research articles used throughout this paper have been collected through various databases, including Google Scholar as well as the databases available through Touro College Libraries such as PubMed and ProQuest.

## Lifestyle Intervention Reducing Incidence of Diabetes

Lifestyle is one of the factors that may impact the presence of type 2 diabetes (Ahmad, Crandall, 2010). Examples of lifestyle characteristics include dietary intake, sleeping patterns, and

physical activity. Recent clinical trials, as well as several large cohort studies, have shown that physical activity can reduce the incidence of type 2 diabetes (Sigal et al., 2004).

Exercise and insulin promote the transfer of GLUT4, a glucose carrier protein, which aids in glucose uptake into the muscles. (Colberg et al., 2010). When we exercise, intramuscular glycogenolysis and glucose uptake are increased to meet metabolic demands for energy. There is often an issue with GLUT4 transport for type II diabetic patients. However, exercise allows for an increase in GLUT4 levels and the movement of GLUT4 to the plasma membrane. Therefore, this becomes a non-insulin dependent pathway for glucose to be transported into the skeletal muscle. This glucose uptake has the potential to be equal to normal glucose uptake in non-diabetics.

The Da Qing IGT and Diabetes Study were one of the earliest randomized trials. It analyzed lifestyle interventions which can prevent type 2 diabetes. Individuals with impaired glucose tolerance (IGT) have a high risk of developing NIDDM (non-insulin dependent diabetes mellitus/type 2 diabetes). The study recruited 577 men and women in a Chinese community who had impaired glucose tolerance. They were randomized into four groups, exercise only, diet only, diet plus exercise and control. The 6-year follow up found that the three intervention groups had a risk reduction of 31-46% versus the control group. The long term-follow up had shown that a majority had progressed to the disease, with a lower risk in intervention groups. Although this study may have shown a significant short term (6 years) risk reduction in diabetes, the long-term follow up showed a minor difference between the groups thus indicating that physical activity may not have such a significant long-term effect (Xiao et al., 1997).

The Finnish Diabetes Prevention Study, a more recent study, analyzed the influence of intensive lifestyle changes in the reduction of diabetes. The study randomly assigned 522 overweight (350 women and 172 men), middle-aged (mean age of 55 years) individuals who had impaired glucose tolerance to a control or intervention group. The subjects in the intervention group received specific exercise guidelines and dietary recommendations. The 3-year follow-up showed a clinically significant impact of the interventions in the reduction of diabetes. The group had a 58% reduced risk compared to the control group. The study also found

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that at least 2.5 hours of moderate to vigorous activity per week caused a 63-69% reduction of diabetes. Furthermore, an extended follow-up revealed that the intervention group maintained a 36% reduction of diabetes incidence. This percentage suggests that benefits can be maintained even after the active intervention was completed. The results of this study clearly show that intensive lifestyle changes (diet and exercise) have the potential to reduce the risk of diabetes in individuals with impaired glucose tolerance (Tuomilehto et al., 2001).

The Diabetes Prevention Program, an additional study of the effect of intensive lifestyle changes, is an even larger randomized controlled trial, recruiting over three thousand overweight, nondiabetic participants with impaired glucose tolerance. The participants were separated into three intervention groups; placebo, metformin (an oral diabetes medicine that helps control blood glucose levels) and intensive lifestyle changes (ILS). The subjects presented with a mean BMI of 34.0 and a mean age of 51 years. Forty-five percent of the subjects were from minority groups, who often display a higher risk for diabetes. The ILS group was given a specific regimen to follow including a low calorie and fat diet and 150 minutes of exercise per week. Furthermore, they joined a 16-week class to learn about diet, exercise, and behavioral modification. Results from a 2.8 year follow up displayed a 58% decrease in diabetes development in the ILS group and 31% reduction in the metformin group compared to the placebo. Results also indicated that weight loss was the main predictor of diabetes reduction (16% reduction per 1 Kg./2.2 lb weight lost). The participants who did not lose the targeted amount of weight but participated in the physical activity still displayed a 44% reduction in diabetes incidence compared to the placebo group. The results support the hypothesis that type 2 diabetes can be prevented or delayed in persons at high risk for the disease. This study shows that specific guidelines, coupled with a wealth of information about health and wellness, can have the potential to impact the incidence of diabetes. The subjects were provided with a lot of knowledge which lasts even after the conclusion of the study. Furthermore, although this thesis does not focus on other forms of diabetes prevention, it is significant to note that physical activity could have a greater effect when combined with additional risk reduction methods such as metformin (Knowler et al., 2002).

A large-scale observational study examined how physical activity impacted the development of type 2 diabetes. The study included 5,990 males from the alumni of the University of Pennsylvania, aged 39–68 years. The subjects were followed for an average of 14 years. A follow-up showed that the disease had developed in 202 of the men. Leisure-time physical activities were measured in kilocalories, and examples included stair climbing, walking, and sports. The study showed that the more the subject participated in leisure-time physical activity, the less likely they were to develop type 2 diabetes. The researchers

observed that for each 500 kcal/wk of activity, there was an average of 6% lower risk of type 2 diabetes. It is important to note that since this study is an observational study, it is less conclusive than the previous randomized controlled trials. Furthermore, the study focused on leisure-time physical activities as opposed to more intensive, regimented exercise. This may have been the reason why there was only a 6% risk reduction. On the other hand, it is nice to see that simply engaging in leisure-time physical activity can have a positive impact on one's physical health (Helmrich et al., 1991).

A study was conducted by the use of a questionnaire and a 12-year incidence report to determine if physical activity reduces the incidence of type 2 diabetes in postmenopausal women (age 55-69). During a follow up 1,997 out of the original 350,000 women had reported a new onset of diabetes. There was a negative association with both moderate and vigorous physical activity and diabetes incidence. Furthermore, the most active women had half the risk of diabetes compared to the least frequently active women. The results of this study also showed that reducing adiposity through participating in physical activity can partially prevent diabetes (Folsom et al., 2000).

### **Lifestyle Intervention Preventing Secondary Risks**

Results of these multiple studies have displayed the role of lifestyle modification, specifically physical activity, in the positive reduction in diabetes incidence. The question remains whether physical activity can also benefit those who are already diagnosed with type 2 diabetes in preventing secondary risks.

Recently diagnosed diabetics were grouped to measure the effect of flexibility, aerobic, and resistive exercises on cardiovascular disease risk factors. These risk factors included lipid profile, exercise capacity, flexibility, glycemic control, and body composition. The outcomes displayed that, body fat triglyceride levels and postprandial glucose levels decreased, while aerobic ability and flexibility increased after exercise. These results led to a decrease in the cardiovascular risk profiles in diabetic patients, thus reducing their intrinsic complications. This study showed that even those already diagnosed with the disease can decrease their risk for secondary diseases that are often associated with type 2 diabetes (Acar et al., 2014).

A similar study also focusing on the secondary risk of cardiovascular disease on type 2 diabetic women showed that physical activity allows for a considerable decrease in high sensitivity C reactive protein levels, fasting glucose and total cholesterol (Alizadeh et al., 2012). On the other hand, it causes high-density lipoproteins to increase. Additionally, the study showed that an eight-week exercise schedule could help lower glycemic and lipid profile, thus reduce the risks of cardiovascular disease in type 2 diabetic women.

A thorough 2005 literature review concluded that regular physical activity provides health benefits in individuals who have

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already expressed clinical diabetes. Indeed, several prospective observational studies have shown that among individuals with impaired fasting glucose or diabetes, higher levels of activity and fitness are associated with a lower incidence of cardiovascular events and mortality from all causes and cardiovascular disease (LaMonet et al., 2015).

A prospective cohort of 1,263 men, who all had type 2 diabetes, was analyzed. The purpose of the study was to evaluate the relationship of mortality in men with type 2 diabetes, with low fitness and physical inactivity. These men were given a thorough medical examination, which included their fitness level and participation in physical activity. A self-reported baseline was used to document their physical activity while fitness was measured by an exercise test. One hundred and eighty subjects died during a 12-year follow up. Diabetic men in the low-fitness group and physically inactive had a two times greater risk for mortality than fit men and active men (Wei et al., 2000).

### Various Forms of Physical Activity

One study meta-analyzed how different modes of exercise training affects glucose control as well as other complications associated with type 2 diabetes. The study included 27 controlled trials involving the estimates for the effect of aerobic training, resistive training, and combined training. There was a total of 1,003 patients with type 2 diabetes that were followed for a 5-104-week period. Results of the meta-analysis indicated that all forms of exercise allow for small-moderate benefits in A1C, the main measure of glucose control. The effects of exercise training seemed to be similar to those of drug, dietary, and insulin treatment. Additional research is imperative to conclude about factors that could affect the outcomes of an exercise program, such as the patient's sex. However, this study indicates that prescribing an exercise program to patients with type 2 diabetes can provide small positive results (Snowling, Hopkins, 2006).

Another study examined the benefits of vigorous activity vs. walking and the incidence of type 2 diabetes in women. The design was a cohort study completed in 1986 (updated in 1988 and 1992). It included surveys of over 70,000 female nurses between the ages 40 to 65 years from the original Nurses' Health Study cohort, which began in 1976. These women did not have a diagnosis of diabetes, cardiovascular disease, or cancer. Although earlier analysis of the original cohort study showed an inverse relationship between vigorous activity and the risk of type 2 diabetes occurrence, there was a lack of evidence regarding the possible role of walking which is a more common form of physical activity in women. In this study, vigorous activity is defined as something which requires 6 METs (metabolic equivalent task-hours) or greater such as jogging, lap swimming, bicycling, etc., as opposed to walking which requires only 2-4.5 METs. The study concluded that both walking and vigorous activity are related to a significant reduction in type 2 diabetes risk in women.

These findings support the current guidelines from the National Institute of Health and the Centers for Disease Control and Prevention that recommend a minimum of 30 minutes of moderate intensity physical activity daily (Webster, 2018).

A randomized control trial was conducted comparing the impact of aerobic training (AT) and progressive resistive training (PRT) on the health status of a multi-ethnic Asian population. Progressive resistive training is a program that builds physical strength by lifting progressively heavier weights and is based on the individual's maximum strength. Both programs were completed over 8 weeks with 60 middle-aged adults who had a diagnosis of type 2 diabetes mellitus. Health status was measured using the Short-form 36 Questionnaire (SF-36), a self-administered assessment measuring eight aspects of functional health. The subscales are divided into the physical component summary score (PCS) and mental component summary score (MCS). Results of the scoring showed significant improvement in both the PRT and AT groups with both physical and mental health benefits. Furthermore, PRT may have some added benefits since there were significant changes in more domains of the SF-36 than in the AT group. Although the benefits of both forms of physical activity are apparent, it is not necessarily certain that the same positive results would apply to a different population. Each population has many factors that can have an impact on health (Ng et al., 2011).

In an additional study, the same questionnaire, SF-36, was completed by subjects which led sedentary lives and were diagnosed with type 2 diabetes. The purpose of this study was to determine if a 10-week moderate aerobic exercise regimen would affect the quality of life (QOL) as well as the physical health of these subjects. The survey was completed by a group of subjects who participated in the training, three days a week for 20-45 minutes. The survey was also completed by the group of control subjects who did not receive the training. Results of this study showed a decrease in percent body fat and an increase in lactate threshold in the training group. However, there was no significant difference in the mental health component of the quality of life survey (Holton et al., 2003).

A study determined if adults with or at risk for diabetes participate in physical activity. A survey was collected by the Medical Expenditure Panel (a nationally representative survey of the U.S. population) regarding the physical activity of 23,283 adults. Additional information such as health conditions (diabetic vs. nondiabetic) and sociodemographic characteristics were self-reported. Results of the survey showed that 58% of adults without diabetes were physically active versus 39% of adults with diabetes. The number of non-diabetic individuals who responded that they were physically active decreased as the amount of type 2 diabetes risk factors increased. Income level, depression, severe obesity (BMI >40kg), and limitations in physical function were the strongest factors correlating with being physically active or not. The study

concluded that those who have type 2 diabetes or those who are at a higher risk for developing the disease do not participate in physical activity regularly. Thus, it is imperative to create efforts to target this population to increase the levels of their engagement in physical activity by reinforcing its value and ability to help curb rising diabetes and obesity epidemic (Morrato et al., 2003).

As previously noted, most American adults who have type 2 diabetes or those who are at risk for developing the disease do not regularly engage in physical activity. A joint positional statement written by The American College of Sports Medicine and The American Diabetes Association concluded that self-efficacy (associated with the confidence in the ability to exercise) and social support are two of the most reliable predictors of greater levels of engagement in physical activity (Colberg et al., 2010). Family, friends, and health care professionals may be a source of support for these individuals. By taking the necessary precautions, individuals with type 2 diabetes can maintain a safe exercise routine. An exercise program or leisure-time physical activity is critical for the overall health of those suffering from this disease.

### Conclusion

Many people assume that high-calorie diets, which are very prevalent in our society (due to fast food, etc.) is the main contributor to obesity and causes a higher risk for diabetes. The studies documented in this research paper highlight another key behavioral factor which contributes to the high rate of this disease. The research has indicated that low physical activity and leading a sedentary life has a great effect on the risk of developing type 2 diabetes. There is also strong evidence that leading an active and fit life has the potential to reduce mortality risk in individuals who already have this diagnosis. Over the past few years, our society has morphed into a technological hub in which the majority of our daily responsibilities can be taken care of with just a few clicks. Thus, it has become common for individuals to be physically inactive and lead sedentary lives. This phenomenon already starts at a young age. For example, our children no longer feel the need to play sports outdoors when they can play the video game version. It is, therefore, imperative to continue researching the effects of physical activity on diabetes risk to bring about global awareness and to halt this fatal epidemic.

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