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Review Article

Effect of stretching exercises on blood gluocse levels in patients with type 2 diabetes mellitus: a brief review

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ABSTRACT

Diabetes has become worldwide pandemic. Among the diabetic population 90-95% patients have type 2 diabetes mellitus (T2DM). The development of T2DM can be slowed down by modification in lifestyle through physical activities such as brisk walking, physical body movement and adopting proper balanced diet. Various physical exercises such as aerobic exercises, resistance exercises, high intensity interval training performed regularly can help with management of blood glucose level, lipid profile, blood pressure, quality of life and cardiovascular complications. Geriatric patients with type 2 diabetes are either extremely frail, wheelchair bound, or bed bound and do not have sufficient physical work capacity to exercise aerobically and with high resistance. Static stretching of the skeletal muscles accrues the benefits of exercise without its accompanying physical stress as in case of aerobic exercise and resisted exercises. Several studies have shown that stretching helps in lowering the blood glucose level in patients with T2DM immediately after the intervention. Till date there are no definitive guidelines are present for stretching exercises as treatment protocol for reduction of blood glucose level and HbA1c level in patients with T2DM. In order to establish a definitive stretching protocol in patients with T2DM and for individual based exercise to be decided further research needs to be conducted.

Keywords: Type 2 diabetes, Stretching, Hba1C, Blood glucose level

INTRODUCTION

Diabetes mellitus is a group of metabolic disease characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both.[1] It is one of the largest global health emergencies of this century, ranking among the ten leading causes of cardiovascular disease, respiratory disease and cancer.[2] Diabetes has become worldwide pandemic. According to WHO, noncommunicable disease accounted for 74% of deaths globally in 2019, of which, diabetes resulted in 1.6 million deaths, thus becoming the ninth leading cause of death globally.[2] Twenty-four million cases of diabetic neuropathy, five million cases of retinopathy and six million cases of amputation due to diabetes were reported by WHO.[3] According to the report of international diabetes federation in 2015, four hundred and fifteen million people suffer from the disease worldwide and the rate will increase to 642 million cases in 2040.[4]

Rapid development has driven as a rapid growing epidemic of diabetes in South East Asia, accounting for close to one-fifth of all cases worldwide.[1] India ranks second after China with 65.1% million diabetes cases that were estimated in 2013.[3] The estimates in 2019 showed that 77 million individuals had diabetes in India, which is expected to rise to over 134 million by 2045.[2] The national family health survey, four survey conducted in fifteen Indian states/ union territories during the year 2014-2015, reported that Andaman and Nicobar Islands had the highest prevalence of the diabetes (26 and 14.5% among men and women, respectively), while Haryana

had the lowest prevalence of diabetes (8.2%) for men and Bihar (6.1%) for women.[2]

Diabetes primarily affects the individuals over the 50 years of age in high income countries, whereas in middle income countries, the prevalence is higher in young individuals, which is the most productive age group.[3] The etiology of diabetes is believed to be multifactorial.[2] Diabetes mellitus is of two types namely type 1 diabetes mellitus and T2DM. Type 1 is also known as juvenile diabetes mellitus and type 2 is also known as adult diabetes mellitus.[5-8] In type 1, which accounts for 5-10% of cases, the cause is an absolute deficiency of insulin secretion resulting from auto-immune destruction of the insulin producing cells in the pancreases. Among the diabetic population 90-95% patients have T2DM. T2DM results from a combination of the inability of muscle cells to respond to insulin properly (insulin resistance) and inadequate compensatory insulin secretion.[1] T2DM, which accounts for majority of the cases, can lead to multiorgan complications, broadly divided into microvascular and macrovascular complications. These complications are a significant cause for increased premature morbidity and mortality among individuals with diabetes, leading to reduced life expectancy and financial and other costs of diabetes leading to the profound economic burden on the Indian health care system.[4]

RISK FACTORS IN DIABETES MELLITUS AND SIGNIFICANCE OF PHYSICAL ACTIVITY

Various risk factors are associated with type 2 diabetes including obesity being the main risk factor for development of type 2 diabetes and other factors are smoking, stress, age, hereditary, alcohol intake. Prolonged T2DM leads to various health related complications such as stroke, cardiovascular disease, retinopathy, neuropathy, nephropathy, gangrene, amputation and death.[9] The main cause for the projected rate is low level of physical activity and unbalanced unhealthy dietary habits.[4]

The risk of diabetes mellitus can be controlled by physical activities and maintenance of a healthy diet. The development of T2DM can be slowed down by modification in lifestyle through physical activities such as brisk walking, physical body movement and adopting proper balanced diet by reducing body weight, and taking oral medications and some patients may also need supplementary insulin.[1,4-7,9] There is an inverse relationship of incidence of type 2 diabetes with higher physical activity and lower leisure sedentary lifestyle.[8] The risk for diabetes is largely influence by ethnicity, age, obesity and physical inactivity, unhealthy diet, and behavioral habits in addition to genetics and family history. Good control of blood sugar, blood pressure and blood lipid levels can prevent and/or delay the onset of diabetes complications.[2-3]

Physical exercise produces short term and long terms effects which reduces the level of HBA1c, blood glucose level, blood pressure, serum lipid profile. Its already proven that regular exercises help in improvement of glycemic control in all types of diabetes. Different kinds of physical activities like muscle stretching aerobic exercises, resistance exercises, yoga, tai-chi improves the tissue /muscle sensitivity to insulin. Physical exercises increase the glucose uptake by skeletal muscles causing the reduction in blood glucose level.[1,3-13]

Physical activities improve the tissue sensitivity to insulin. Physical activities including muscle stretching, aerobic training, resistance training, high intensity interval training, yoga etc. help in improving glycemic control in all types of diabetes mellitus. Physical exercise produces short term and long terms effects which affects the level of HbA1c, blood glucose level, blood pressure, and serum lipid profile. Several studies have shown that there is significant effect of aerobic exercise and resistance exercise and combined effect of both on reduction of blood glucose level.[8,11,13-15]

Various physical exercises such as aerobic exercises, resistance exercises, high intensity interval training performed regularly can help with management of blood glucose level, lipid profile, blood pressure, quality of life and cardiovascular complications.[4,8,9,11,13] Research studies have concluded that training interventions such as aerobic and or resistance training offered by a physiotherapist helps in lowering the blood glucose level by 0.5-0.8% in HbA1C.[1]

Aerobic exercises such as running, walking, cycling, swimming performed at moderate intensity is effective in increasing glucose utilization by muscles, cardiovascular fitness, quality of life, depression status of patients with diabetes mellitus over twelve weeks of exercise program. The American diabetes association recommends aerobic activity that last for at least 10 minutes with a goal of 30 minutes/day or more and done for almost every day of the week is effective in adults with T2DM.[3]

Resistance training at any intensity is recommended for adults with diabetes. Resistance exercises has a positive impact on elderly patients it reduces the restrictions in motor functions in elderly patients. Combinations of resistance and aerobic training is also effective in improvement of muscle strength, glycemic control and quality of life in moderately affected type 2 diabetic patients.[13]

But there are several limitations such as some of the studies didn't include supervised exercise program in which it could not determine whether patients completed the exercise program or not. Some studies ended without follow up in which long term effects could not be observed, also exercises were not categorized by age, because age is said to affect the body's metabolic rate.[13]

STRETCHING IN PATIENTS WITH T2DM

For some individuals, the secondary complications arising from diabetes such as lower limb neuropathies, lower limb amputations, hypertension, kidney disease and retinopathies can either contraindicate exercise or make it more difficult. Geriatric patients with type 2 diabetes are either extremely frail, wheelchair bound, or bed bound and do not have sufficient physical work capacity to exercise aerobically and with high resistance and that's why stretching protocol are required.[4,10]

Physiotherapists offer evidence-based training interventions encompassing aerobic training and/or resistance training. Three meta-analyses showed that both of these training modalities are effective in lowering the blood glucose by 0.5-0.8% in HbA1c (blood glucose control). It is possible to prevent or delay the onset of T2DM by reducing lifestyle risk factors through moderate weight loss and increased physical activity. Several studies have shown that lifestyle changes that include exercise can significantly delay and possibly prevent diabetes. Although regular physical activity, may prevent or delay diabetes and its complications, most people with T2DM are not active.[4,10]

Static stretching of the skeletal muscles accrues the benefits of exercise without its accompanying physical stress as in case of aerobic exercise and resisted exercises. It is advantageous treatment for those with reduced physical capabilities and can be done without any additional equipment, facilities, or other expenses. Thus, it should easily fit into the repertoire of treatment modalities of people with T2DM.[1,4,5,7,10,12] Static stretching involves holding a muscle in challenging but comfortable position for 30 seconds without moving the extremity during the stretch. Active stretching is performed by the subjects independently whereas passive stretching involves a stretch applied by the therapist or by any other external force.[5]

There are several possible mechanisms as to why blood glucose level has decreased following passive stretching. Mechanical stimuli such as stretching increases glucose transport and glycogen metabolism in skeletal muscle and effects of stretching are not dependent on insulin-signaling pathway. The Glycogen content of stretched muscles decreases as compared to muscle groups which are not stretched. GLUT-4 is the glucose transport protein and is the main mediator for glucose transport into the skeletal muscles. Exercise increases GLUT-4 levels in the skeletal muscles.[1,4,5,7,10,12]

Several studies have shown that stretching helps in lowering the blood glucose level in patients with T2DM immediately after the intervention (Table 1).[1,4-7,10,12]

Studies have supported that stretching could results in better glycemic control, improve joint mobility and muscle function in diabetic patients. Recently new form of physical activities such as active and passive stretching are also reported in treatment of patients with T2DM.

Table 1: Summary of studies conducted on diabetic patients using stretching as an exercise intervention.

Authors, journal, year	Objectives	Designs	Characteristics of participants sample size	Methods	Outcome measures	Results	Limitations
Nelson et al, 2011.[10]	Twenty minutes of passive stretching lowers glucose levels in an at-risk population: an experimental study	Randomize, within participant design experimental study	N=22, (17 males and 5 females). Adult participants having at least three of the following four risk factors: sedentary, aged at least 45 years, BMI at least 25 kg/m² and family history of T2DM	After 30 minutes of fruit juice intake, experiment group-passive static stretching of 6 lower body and 4 upper body muscles for 40 minutes, Control group-mock passive stretching of 6 lower body and 4 upper body muscles for 40 minutes	Blood glucose level obtained at baseline, during the regimen (20 min.), after the regimen (40 min.)	Passive static stretching exercises are more significant in reducing blood glucose level in T2DM	Immediate effects of stretching was ascertained by this study.
Solomen et al, 2015.[1]	Passive stretching versus active stretching on immediate blood glucose in subjects with T2DM: a pilot study	pre-post experimental study	N=20, participants with history of T2DM for more than 10 years, HbA1c value ranged between 6-8	After 30 minutes of fruit juice intake, Group A (n=10)-passive static stretching of 8 lower limb muscles for 40 minutes, group 2 (n=10)-active stretching of 8 lower limb muscles for 40 minutes	Blood glucose level before and after 40 minutes of stretching	Compared to active stretching, passive stretching resulted in greater reduction in the blood glucose level	Difficulty to perform the stretch in full rom, insufficient sample size, long trial interventions were not performed to determine the improvement in glycemic control.

Continued.

Authors, year	Objective	Design	Characteristics of participants sample size	Methods	Outcome measures	Results	Limitations
Park, 2015[12]	Effects of passive static stretching on blood glucose levels in patients with T2DM	Randomized control trial	N=15, (8 males and 7 females). Participants diagnosed with T2DM confirmed by HbA1c level 6.5% or higher, participants with sedentary lifestyle and who is willing to commit to 8 weeks supervised exercise program	Control group (n=7)- instructed to maintain their diet + medication, passive static stretching group (n=8)-passive static stretching of 6 lower body and 4 upper body muscles for 40 min	HbA1c value before and after the 8 weeks intervention period	HbA1c level decreased significantly in the passive static stretching group after the intervention	Insufficient sample size to generalize the results to all patients with T2DM, short intervention period to determine the changes in blood glucose level as a result of stretching.
Gurudut, 2017[6]	Immediate effect of passive static stretching versus resistance exercise on postprandial blood glucose levels in T2DM: a randomized clinical trial	Double blinded randomized controlled trial	N=51, Between the age group of 40-65 years, diagnosed with type 2 diabetes for more than 4 years, participants taking oral hypoglycemic drugs, having sedentary lifestyle and baseline HbA1c value greater than 6.6%	Exercise regimen was carried out 2 hours after meal. exercise regimen consisted of 10 minutes warm up phase, 40 min intervention phase and 10 minutes cool down phase. PSS group (n=25)-passive static stretching of 4 upper limb and 4 lower limb muscle group bilaterally, RE group (n=26)-resistance exercises with the help of weight machine, dumbbell and TheraBand for 60 minuets	Blood glucose level -fasting blood glucose level at baseline and postprandial blood glucose level before and after intervention.	Study concluded that both passive static stretching and resistance exercises are equally beneficial intervention in reducing postprandial blood glucose level.	Long tern effects were not studied, HbA1c value was not assessed.
Taheri et al, 2018[4]	The effects of passive stretching on blood glucose levels of patients with type 2 diabetes	Randomized clinical trial	N=50, (40 male and 10 female) diabetic patients aged 40-65 years with a body mass index between 22-25 kg/m², participants with history of more than 6 months of diabetes and fasting blood glucose more than 126 mg/dl.	Participants randomly divided into two groups Passive stretch group (n=25)-passive stretching of 4 upper body and 6 lower body muscles for 20 minutes, passive movement group (n=25)-passive movement of upper and lower extremity without any sensation of muscle stretch.	Blood glucose level before the stretch and immediately, 20 minutes and 1 hour after the stretch	Blood glucose level immediately, 20 minutes and 1 hour after the intervention were significantly low in passive stretching group as compared to the passive movement group	Small sample size, short duration of intervention.
Elgayar, 2019[5]	Active versus passive stretching exercises on blood glucose and functional capacity in elderly diabetic patients: comparative study	A randomized controlled comparative study	N=50 (50 males) Type 2 diabetic men with age ranged from 60 -70 years, diagnosed with T2DM with HbA1c value from 6.5% to 8.0%, duration of diabetes from 4 to 6 years, all patients were on oral hypoglycemic drugs at the same dose.	All patients randomly divided into 3 groups, group A (n=20)-treated with active stretching exercises for 40 min, group B (n=20)-treated with passive stretching exercise for 40 min, group C (n=10)-control group received no treatment, stretching exercise protocol conducted 3 times per week for 12 weeks.	HbA1c level and 6 minutes walk test before and after treatment, Postprandial blood glucose level at beginning, immediately after and the end of the session.	Both active and passive stretching exercises improve glycemic control and functional capacity in elderly diabetic patients with no difference between them.	Study was limited to males which were only available, diet of the subjects was not controlled, the sample size was insufficient to generalize the results.

Continued.

Authors, journal, year	Objective	Design	Characteristics of participants sample size	Methods	Outcome measures	Results	Limitations
Shirodkar et al, 2022[7]	Effect of static stretching on random blood sugar levels in T2DM: a randomized clinical trial	Experimental study	N=40, patients between the age group of 40-55 years, diagnosed with T2DM for more than 4 years, on oral hypoglycemic drugs, patients who have sedentary lifestyle and had recent baseline HbA1c value of greater than 6.6%.	Patients divided into 2 groups, control group (n=20)-dietary advise + home exercise, experimental group=static stretching of 4 upper and lower body muscles for 24 minutes. Total session duration was 30 minutes, frequently 2-3 days per week for 8 weeks.	Random blood sugar levels were taken at week 1 and week 8	static stretching is effective in reducing blood sugar level and improves the quality of life in subjects with T2DM.	Random blood sugar level has been used as an outcome measure, no follow up of the subjects was done, HbA1c level was not measured, less number of sessions per week.

STRETCHING PROTOCOL FOR PATIENTS WITH T2DM

Several studies have shown that stretching helps in lowering the blood glucose level in patients with T2DM.[1,4-7,10,12] Studies have supported that stretching could results in better glycemic control, improve joint mobility and muscle function in diabetic patients. Recently new form of physical activities such as active and passive stretching are also reported in treatment of patients with T2DM.

Studies proved that passive static stretching is an effective intervention that can be prescribed specifically at postprandial stage that is 2 hours after the meal for diabetic individuals who have difficulty in controlling the postprandial spike in blood glucose. Passive static stretching helps in reducing postprandial blood glucose level immediately after the intervention.[1,6,10] It is also proved that passive static stretching has significant effect on reduction of fasting blood glucose level immediately after the intervention.[4] Studies have proved that long term effects (8 weeks, 12 week) of static stretching exercise help in reduction of blood glucose HbA1c level.[6]

Studies conducted till date could not conclude definitive conclusion for framing a definitive protocol of stretching exercises in patients with T2DM due to multiple limitations in all the studies like insufficient sample size, long trial interventions were not performed to determine the improvement in glycemic control, limited to male gender only, involved less than three stretching sessions per week and proper outcome measures were not used. Till date there are no definitive guidelines are present for stretching exercises as treatment protocol for reduction of blood glucose level and HbA1c level in patients with T2DM.[1,4-7,10,12]

Hence, in order to establish a definitive stretching protocol in patients with T2DM and for individual based exercise to be decided further research needs to be conducted.

CONCLUSION

Physical activities including muscle stretching, aerobic training, resistance training, high intensity interval training, yoga etc. help in improving glycemic control in all types of diabetes mellitus. Physical exercise produces short term and long terms effects which affect the level of HbA1c, blood glucose level, blood pressure, and serum lipid profile. Various physical exercises such as aerobic exercises, resistance exercises, high intensity interval training performed regularly can help with management of blood glucose level, lipid profile, blood pressure, quality of life and cardiovascular complications. Geriatric patients with type 2 diabetes are either extremely frail, wheelchair bound, or bed bound and do not have sufficient physical work capacity to exercise aerobically and with high resistance and that's why stretching protocol are required. Several studies have shown that stretching helps in lowering the blood glucose level in patients with T2DM immediately after the intervention. Due to multiple limitations in studies conducted till date, no definitive protocol of stretching exercises in patients with T2DM could be framed. In order to establish a definitive stretching protocol in patients with T2DM and for individual based exercise to be decided, further research needs to be conducted.

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