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Passive stretching versus active stretching on immediate blood glucose in subjects with type II diabetes mellitus - A pilot study

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Abstract
Background: Physical activity is the key element in prevention and management of Type II Diabetes mellitus. Physiotherapy interventions such as Endurance exercise, Progressive resistive exercises and Stretching exercises can lower blood glucose in patients with Type II Diabetes. It is not known that whether the active stretching or the passive stretching is better in reducing the glucose level in patients with Type II diabetes. Objective of the study was to find out the immediate effects of active stretching exercises and passive stretching exercises in lowering blood glucose level in patients with Type II diabetes.
Methods and Material: 20 subjects with history of diabetes of more than 10 years with glycosylated haemoglobin (6-8) % were referred by the physician. Subjects in group A underwent 40 minutes of active stretching of lower limb and group B subjects underwent passive stretching of the same muscle groups for 40 minutes. Blood glucose levels were measured before and after 40 minutes of stretching.
Results: Both groups showed statistically significant results in blood glucose immediately after stretching. Compared to active stretching, passive stretching resulted in significantly greater reduction in the blood glucose level ($p < 0.05$).
Conclusions: Results suggest that active stretching and passive stretching of skeletal muscle may be an alternative to resisted exercises to lower the blood glucose level. However, comparing between groups passive stretching was better than active stretching in reducing the blood sugar level.

Keywords: Stretching, Blood glucose, Physiotherapy, Diabetes

1. Introduction

Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The chronic hyperglycemia of diabetes is associated with long-term damage, dysfunction, and failure of various organs, especially the eyes, kidneys, nerves, heart, and blood vessels [1]. This result in negative severe outcomes such as retinopathy, nephropathy, neuropathy, cardiovascular disease, stroke, pressure ulcers, neuropathic wounds, loss of peripheral protective sensation, gangrene, limb amputation and death [2].

The major forms of diabetes can be categorized as type 1 or type 2. 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 pancreas. T2 DM (90%-95% of cases) results from a combination of the inability of muscle cells to respond to insulin properly (insulin resistance) and inadequate compensatory insulin secretion. Less common forms include gestational diabetes (GDM), which is associated with a 40%-60% chance of developing T2DM in the next 5-10 year. Diabetes can also result from genetic defects in insulin action, pancreatic disease, surgery, infections, and drugs or chemicals [1].

Rapid development has driven a fast-growing epidemic of diabetes in South-East Asia, accounting for close to one-fifth of all cases worldwide. The majority of the 382 million people with diabetes are aged between 40 and 59 [3]. More than 50 million Indians are struggling with the diabetes with about 1 million deaths in India, more than in any other country [4]. Physiotherapists offer evidence-based training interventions encompassing aerobic training and/or resistance training [5]. 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) [6-8]. It is possible to prevent or delay the onset of Type 2 diabetes 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 [9, 10]. Although regular physical activity (PA) may prevent or delay diabetes and its complications, most people with T2 DM are not active.

Nelson *et al*. conducted a study on effectiveness of stretching on blood glucose in subjects with Diabetics and subjects those who are at risk and the author concluded that twenty minutes of passive stretching lowers glucose levels in an at risk population.[2] 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 an additional viable activity that can help regulate blood glucose acutely. Since it requires little effort by the individual, it appears to be an advantageous treatment for those with reduced physical capabilities. Also, it 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 Type 2 diabetes.

Research points to the possibility of stretching increasing GLUT4 incorporation. The protein kinase B activity partially controls GLUT 4 incorporation and activation, and Sakamoto *et al*. in 2003 found that protein kinase B was stimulated by passively stretching isolated muscles for ten minutes.[11] The mitogen activated protein kinase activity stimulates muscle cell glucose uptake, [12] and the activity of mitogen activated protein kinases directly reflects the magnitude of the mechanical stress (i.e., actively or passively generated tension) applied to the muscle [13]. Also, exercise-induced increases in nitric oxide result in increased glucose transport [14]. Finally, ischemia can increase GLUT 4 translocation to the sarcolemma as well as increasing glucose uptake [15, 16]. In addition, Poole and colleagues reported that muscle stretching reduces bulk blood delivery, alters capillary flow dynamics, and impairs blood tissue oxygen exchange [17].

The diabetes patients could realise better blood glucose control and health at a substantial financial saving if a stretching program (either passive or active) under the supervision of a physical therapist or other trained personnel was established. It is a known fact that stretching daily for 20-40min has the metabolic rate similar to the rate estimated for walking 40m/min[18]. These findings, coupled with the results of this study, suggest that stretching may help a person to control or lower blood glucose levels. But it is not known whether which of the two active or the passive stretch is more effective. The active stretch would have a patient perform the task at his own taking into the account the expenditure of energy in performing the task whereas the passive stretch would not incorporate the additional expenditure but would substitute it in gaining extra lengthening of the stretched muscle which would not have been possible when done actively or by active stretch. The physical limitation may be due to pain perceived by the extra lengthening of the muscle during passive stretch. Thus there is a need to determine which of these stretches would actually benefit in an efficient and effective way to reduce the blood glucose level. Thus the objective of the study was to find out the immediate effect of active stretching exercises and passive stretching exercises in lowering blood glucose level in patients with type II diabetes.

2. Materials and Methods

The study was conducted at Padmashree physiotherapy clinic, Bangalore. Ethical clearance was obtained from institutional ethical committee, Padmashree Institute of Physiotherapy, Bangalore as per ethical guidelines for biomedical research on Human subjects, 2001 ICMR, New Delhi. The study design was a pre-post experimental study. Twenty participants with a history of Type II diabetes mellitus for more than 10 years and HbA1c (values between6-8) were referred by the physician included in the study. Subjects who were unwilling or unable to complete the study or had any kind of lower limb contracture were excluded. Prior to participation, a written-informed consent was taken from all subjects and subjects were informed about study protocol. Participants (Group A-10; Group B-10) reported to the laboratory two hours after eating a meal, and immediately drank a 355 ml can of fruit juice (~43 gm carbohydrate). Thirty minutes after drinking the fruit juice, participants in group A underwent a 40-min passive static stretching regimen and group B participants went through 40 min active stretching supervised by the therapist.

The intervention included passive and active stretching programs of 8 lower limb muscles in group A and group B participants respectively. For each stretch, the muscle was held in a stretched position for 45 seconds and was repeated four times. A 15 second relaxation period separated each repeat, and a minimum 30 seconds separated the different stretches. For those stretches that stretched a single limb, the right limb was stretched first, and all the four stretches were completed before starting on the left limb. In each instance, the therapist received verbal acknowledgement that the stretch was felt by the participant & then constant pressure on the participant's body part was maintained for 45 seconds. At the end of the stretch the body part was returned to the neutral position for 15 seconds. The stretches included both active and passive stretching for the following muscles: gluteus maximus, iliopsoas, hamstrings, quadriceps, rectus femoris, hip adductors, gastrocnemius and soleus. Blood glucose levels were determined before and after 40 minutes of intervention in both groups. Blood glucose levels were analysed by random glucose method.

Data analysis was performed using SPSS software (version 17). Alpha value was set at 0.05. Descriptive statistics was used to find out mean and standard deviation (SD) for demographic and outcome variables. Unpaired t test used to analyse the demographic variables such as age and $Hb_{A1}C$. Chi-square test was used to test for gender difference among both groups. Paired t-test was used to analyse significant difference with in groups for the blood glucose value. Unpaired t-test was used to analyse significant difference between groups for the blood glucose value.

3. Results & Discussion

3.1 Results

Base line characteristics of 20 subjects for both groups are shown in Table 1. Comparison of groups for blood glucose showed no statistical significant difference at base line (p <.698). Both groups showed statistically significant reduction in blood glucose after immediate stretching (p<.0001). However when comparing between groups, there was more statistical significant reduction in group A who received passive stretching (p<.036) which is mentioned in Table 2.

Table 1: Baseline data for demographic variables

Variable	Group A	Group B	Þ- value
Age	60.00 ±3.92	61.90 ± 2.38	> 0.206
Gender (M/F)	6/4	5/5	> 0.500
HbA1c	7.01 ± 0.26	7.11 ± 0.33	> 0.465

Table 2: Pre-post data within and between groups

Group	Pre	Post	Within group Þ- value
Group A	250 ± 24.04	166.40 ± 22.56	< 0.0001
Group B	253.40 ± 11.03	184.60 ± 11.71	< 0.0001
Between group Þ- value	> 0.698	< 0.036	

3.2 Discussion
The objective of the study was to find out the immediate effect of active stretching exercises and passive stretching exercises in lowering blood glucose level in patients with type II diabetes. The study design was a pilot study with pre post-test design. The demographic variables were taken was age and HbA1c. The base line data of the demographic and outcome variables did not show any statistically significant difference between the groups.

In the present study group A which underwent for passive stretching had significant improvement in blood glucose. The group B which underwent active stretching also had significant improvement in blood glucose. There was statistically significant improvement in the blood glucose for both of these groups. This was in accordance with the study done by Nelson *et al.* [2] which concluded that passive static stretching of the skeletal muscles may be an alternative to exercise to help lower blood glucose levels. However in that study subjects were either with type 2 Diabetes or at increased risk of type 2 diabetes. There are several possible mechanisms as to why blood glucose concentration has decreased following both active and passive stretching.

There have been many studies that have related the stretched muscle to be metabolically active. Feng in his study stated that the resting metabolism of a muscle is directly related with stretch, demonstrated both by heat and by oxygen consumption. According to author more the stretch, more will be the muscle metabolism. The author referred this as "stretch response". According to the study by N. F. Clinch which supports that there is increase in rate of heat production with increase in stretch, further author also supports that the stretch response is associated with the appearance of tension in the sarcolemma.

According to Masahiro Iwata [21], mechanical stimuli such as stretch increase glucose transport and glycogen metabolism in skeletal muscle. The effects of stretch-stimulated glucose transport are independent of the insulin-signalling pathway. Glycogen content of stretched muscles decreases in compared to unstretched muscles. According to William S. Barnes [22], Oxygen consumption was found to be linearly related to increase in load and Lactate released into the medium was inversely related to load which suggested that as stretch-related oxidative energy metabolism increases, there is a lessening dependence on anaerobic energy-yielding processes

Evidence suggests that the possibility of stretching increases the GLUT4 incorporation. The protein kinase B activity partially controls GLUT 4 incorporation and activation. Sakamoto and colleagues [23] found that protein kinase B was stimulated by passively stretching isolated muscles for ten minutes. The amount of GLUT-4 protein is a primary factor in determining the maximal rate of glucose transport into skeletal muscle. The abundance of Glut isoforms may be better related to the muscle's oxidative capacity. The mitogen activated protein kinase activity stimulates muscle cell glucose uptake [12], and the activity of mitogen activated protein kinases directly reflects the magnitude of the mechanical stress (i.e., actively or passively generated tension) applied to the muscle [13].

Ischemia causes substantial translocation of GLUT4 molecules. According to Sun *et al.* [15], a combination of insulin plus ischemia stimulates an even greater degree of GLUT4 translocation. GLUT4 translocation is likely to mediate at least part of the increased glucose uptake. Ischemia can increase GLUT 4 translocation to the sarcolemma as well as increasing glucose uptake. In addition, Poole and colleagues [17] reported that muscle stretching reduces bulk blood delivery, alters capillary flow dynamics, and impairs blood tissue oxygen exchange.

According to Roberts *et al.* [14], exercise-induced increases in nitric oxide result in increased glucose transport. Tidball *et al.* [24] also found that the changes in muscle activation & loading regulate the expression and activity of neuronal nitric oxide which significantly increases NO by a single passive stretch of 20%. The increased NO release resulting from passive stretch or activation was dependent on the presence of extracellular calcium.

In between group analysis, it was found that the group which underwent passive stretching showed more reduction in blood glucose as compared to the group which received active stretching. This may be explained by many possible reasons. Firstly, passive stretch increases glucose transport in muscle with direct relation with the force generated during the stretch. According to Jacob Ihlemann, glucose transport varies directly with force development. Whereas in active stretching the force generated is influenced by the one's commitment to achieve flexibility and the person's ability to perform a particular stretch. Therefore the adequate force generated in active stretch can be achieved only by thorough learning and practice over the course of time. Secondly, passive stretch could generate greater stretch response when compared to active stretch. Because the tension in passive stretch increases in an exponential fashion whereas the tension in active stretch has three regions or limbs i.e. ascending limb, plateau limb, and descending limb. The increase in tension is due to the increase in length which in turn increases the metabolic activity of the muscle. The other possible mechanism could be variability in the level of ischemia during the stretch intervention and passive stretching have a greater component of muscle ischemia than active stretching.

A limitation of the study was that some of the participants were performing the physical activity for the first time due to which the stretches were difficult to perform in full ROM. Further research should focus on enlisting higher number of patients in a randomized controlled trial. Research should also address the possible additive benefits of combine stretch with either aerobic or resisted exercises. Long term trials would also be beneficial to determine how improvements can be seen in glycemic control such as on Hb 1Ac Values.

4. Conclusion
Study concludes both active and passive stretching of skeletal muscle is effective in blood glucose control. However passive stretching was better than active stretching in reducing the blood sugar level. Thus patients who are physically inactive, obese, arthritic, neurological patients affecting balance and co-ordination and very old patients, passive stretching can be an alternative method of treatment to lower blood glucose preferred to aerobic and resisted exercises.

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