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PHYSIOTHERAPY AND REHABILITATION IN THE MANAGEMENT OF DIABETES MELLITUS: A REVIEW

JASPREET KAUR[a1], SHAILENDRA KUMAR SINGH[b] AND JASPREET SINGH VIJ[c]

[a]Department of Physiotherapy, G.J.University of Science & Technology, Hisar ,India
[b]Department of Pharm. Sciences, G.J.University of Science & Technology, Hisar ,India
[c]College of Physiotherapy, Baba Farid University of Health Sciences, Faridkot, India

ABSTRACT

The purpose of the present review is to find out effect of exercises on complications like muscular strength, gait, balance, quality of life in patients suffering from Diabetes Mellitus. The present study also reveals the contribution of exercises in improving these factors.The results of the various studies included in this manuscript reveals that exercises improve quality of life(QOL) of patients suffering from diabetes mellitus is improving with exercise interventions but still extensive research needs to be done to further improve the QOL with respect to both physical and mental QOL. Lot of researches included in this manuscript state that when exercises are included in routine it helps in lowering blood glucose levels studies also reveal that exercises have proved to be beneficial in improving muscular strength, balance, gait, and fall related problems.

KEYWORDS : Diabetes mellitus, Gait, Balance, Strength, Quality of life

Advances in socio-economic development, daily routines, changes in dietary habits, aging and sedentary life style have manifested into significant rise in number of patients suffering from diabetes mellitus, hypertension, various musculoskeletal disorders and rise in obesity(Zimmet, et al; 2001, Li M.Z, et al; 2013, Sena, et al; 2010). Diabetes mellitus has become leading health problem throughout the world irrespective of developing and developed countries(Li M.Z, et al; 2013, Qibin& Frank; 2012). Diabetes has become global health problem and its complications have led to rise in mortality and morbidity. As the number of patients suffering from diabetes is increasing, it has become very essential to quantify the prevalence so that resources are allocated properly.

Epidemiology

Lot of data has been collected globally to know the exact number of patients(Wild, et al 2004, Soriguer, et al; 2012). Incidence of diabetes in Japan show that every 9th person in 1000 suffer from diabetes , which is increasing rapidly due to increase in obese population, decline in physical activity and aging(Goto, et al; 2013). Spanish population shows 13.8% prevalence of diabetes which is based on obesity, abdominal fat, high BP, low HDL-cholesterol, high triglycerides and family history of diabetes(Soriguer, et al; 2012). In Mexico Diabetes Mellitus rose drastically from year 1944 to 2006, from 0.7% in 1994 to 7.5% in 2000 and 14.4% in 2006 both in males and females(Barquera, et al; 2013)whereas in Australia the figure has increased threetime since 1981 as AusDiab reported 7.4% increase in year 2000(Shaw &Chisholm ; 2003). Global figures reveals a drastic rise in diabetes, it is shown in figure 1.

In year 2000, 171 million patients were suffering from diabetes (Wild, et al.; 2004). Hilary King and Ronald E. Aubert et al (1998) predicted that by year 2025 patients suffering from diabetes may rise to 300 miilion (King H, et al ;1998) which will have to be reconsidered as diabetic population has already risen to 387 million in 2014 (IDF 2014) figure 2 (if seen continent wise were 387 million which include North America & Caribbean (NAm&C),South and central America (S&Cam), Europe, Middle East and North Africa(ME&NAf), Africa, South East Asia(SEAs), Western Pacific(WP)). Further estimates done by J.E.Shaw, R.A.Sicree et al. (2010) show that by year 2030 the incidence of diabetes mellitus will increase to 439 million. Out of this population 69% will be in developing countries and 20% in developed countries (Shaw JE , et al; 2010). Recently L. Guariguata , D.R. Whiting (2014) predicted that diabetes may rise to 592 million by year 2035, which is an alarming figure 2.

India has become diabetes capital of the world. Diabetics are increasing with alarming figures. Every fifth diabetic in world is Indian (Joshi &Parik ; 2007).In 2000 people suffering from diabetes were 32 million which rose to 40.9 million in 2007 and it is expected that they will rise to 69.9 million and 80 million by 2025 (Mohan, et al ; 2007).

[1]**Corresponding author**

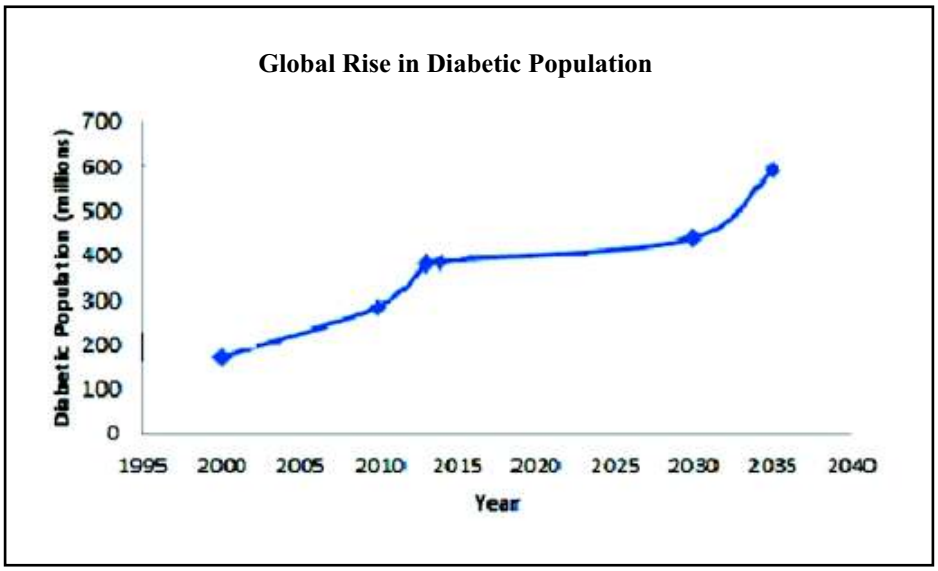

Figure 1 : Global Rise in Diabetic Population

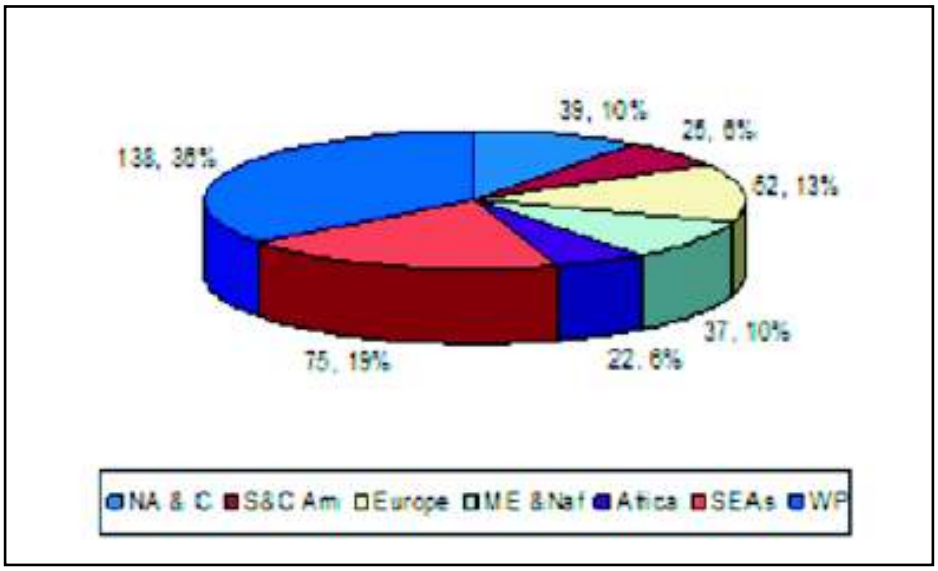

Figure 2 : Continent Wise Prevalence of Diabetes

The two different studies done in north India and South India states that urban population suffers more from Diabetes than rural population (Misra et al, 2001 &Ramchandra, et al ; 1988). Most of the studies are done in major cities of India but no national survey covering all the states (including rural areas) is conducted till date which is need of hour so that accurate number is obtained.

Types, Signs and Symptoms

Diabetes mellitus is a group of metabolic diseases characterised by hyperglycaemia due to underutilization and over production of glucose(ADA;2006 & WHO;1999). The common symptoms include polyuria, polydipsia, weight loss, sometimes accompanied with polyphagia, blurred vision(ADA;2006). The disease is classified into several categories (figure 3). But out of these two are broadly described, these are Type 1 (insulin dependent diabetes mellitus) and Type 2 (non insulin dependent diabetes mellitus). WHO (1999) recommended to classify DM by both staging of DM based on clinical descriptive area and an aetiological classification (figure 3).

Table 1 : Criteria for Diagnosing DM

1. Symptoms of diabetes plus casual plasma glucose concentration ≥200mg/dl. Casual is defined as any time of day without regard to time since last meal. The classic symptom of diabetes mellitus include polyuria, polydipsia, and unexplained wt loss. Or
2. FPG≥126mg/dl. Fasting is defined as no caloric intake for atleast8h Or
3. 2-h PG≥200mg/dl duingan OGTT. The test should be performed in accordance with WHO Guidelines, using a glucose load containing the equivalent of 75 g anhydrous glucose dissolved in water

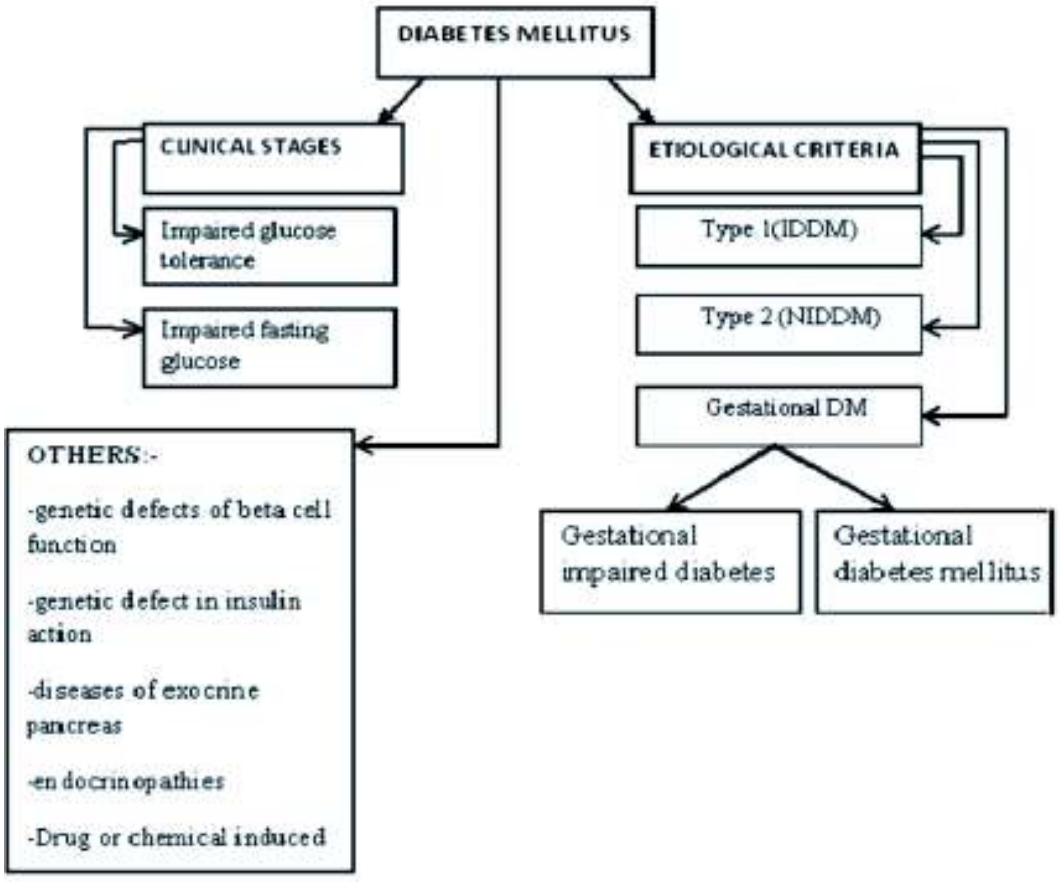

Figure 3 : Types of Diabetes Mellitus

Impaired glucose regulation (IGT & IFG) is the stage between normal glucose levels and DM. IGT is categorized as a stage rather then classification is natural history of disordered carbohydrate metabolism. Similarly IFG is categorised as a stage it refers to fasting glucose concentration which are lower than those required to diagnose diabetes mellitus but higher than the normal. IGT and IFG are not clinical entities n their own right, but rather

Table 2 : Normal and Abnormal Values For OGTT and FPG

FPG Values	OGTT Values	Remarks
FPG < 100mg/dl (5.6 mmol/l)	2-h postload glucose < 140 mg/dl (7.8 mmol/l)	Normal glucose tolerance
FPG= 100-125 mg/dl(5-6-6.9 mmol/l)	2-h postload glucose 140-199 mg/dl (7.8-11.1 mmol/l)	Impaired glucose tolerance
FPG ≥126 mg/dl (7.0 mmol/l)	2-h postload glucose > 200 mg/dl (11.1 mmol/l)	Provisional diaganosis of diabetes

risk categories for future diabetes. Further normoglycaemia classified as another stage in which persons who have evidence of pathological process which may lead to DM or in whom a reversal of hyperglycaemia has occurred (WHO;1999).

Aetiology

The most broadly known types of Diabetes are Type 1 and Type 2 Diabetes Mellitus. Type 1 diabetes also known as juvenile/Insulin Dependent Diabetes Mellitus (IDDM) and Type 2 Diabetes also known as NIDDM is caused by many factors which include genetic, environmental and factors that disrupt the insulin absorption or secretion. Type 1 diabetes is result of damage to the insulin producing beta cells in the pancreas which further result in lack of insulin. As it is an autoimmune disease, the body's immune system attacks and destroys beta cells. The genetic factors account for about 1/3rd of the susceptibility of type 1 DM, the inheritance is polygenic. Type 2 diabetes mellitus (NIDDM) is caused by a combination of insulin resistance as body's fat, muscles, and liver cells do not use insulin effectively. It usually occur in overweight/obese middle aged and older people. But now a days it has become common in children and adolescents too(Sena et al ; 2010).

Further environmental factors are also responsible in increasing the incidence of diabetes. Various viral infections like mumps, coxasackie B4, Retrovirus, rubella etc may induce type 1 diabetes mellitus. Lifestyle that leads to under activity and obesity are associated with type 2 DM. Also malnutrition in utero which leads to low birth weight is found to cause DM in late adulthood(Sena et al.; 2010).

Diagnosis of Diabetes Mellitus

Normally when patient complains of symptoms suggesting diabetes the urine test is advised for glucose and ketones. Typically blood glucose, urinary glucose, ketone testing, HbA1c., Oral Glucose tolerance test(OGTT) are the tests used to analyse diabetes (WHO ; 1999, Seino et al 2010). Further criteria has been laid down by ADA for diagnosing diabetes illustrated in table 1(ADA ; 2006).

Glucose and OGTT

Hyperglycaemia being the main feature of testing blood glucose, specifically blood plasma. For many years this was accepted as main diagnostic tool(Sacks et al 2011). later ADA in 2006 modified the values (table-2) and stated that if any one of these criteria of FPG is met then confirmation should be done by repeating the test on subsequent day. while drawing the sample from an individual it should be only drawn when individual has fasted overnight atleast 8 hour as there are variations in FPG with the mean FPG higher in the morning than in afternoon(ADA ; 1997, Troisi et al ; 2011).Because there is increased secretion of growth hormone at night and also of cortisol in early morning (Troisi et al ; 2011). Urinary Glucose level, a not very popular diagnostic tool, is only performed when patient either is unable or refuses to perform self-monitoring of blood glucose (SMBG). It is also done in conditions where testing blood glucose is not accessible or unaffordable(Sacks et al 2011, Goldstein et al ; 2004, IDF ; 2005). Other reasons for not choosing SMBG may be its low accuracy, amount of fluid intake, intake of certain drugs, inability of the test to distinguish hypoglycaemia, euglycaemia and hyperglycaemia, etc (Goldstein et al ; 2004).

Ketone Testing

Ketones are measured in both urine and blood to diaganose diabetes. Dipsticks and tablets are used to measure ketones both in blood and urine. The presence of ketones in urine establishes the possibility of diabetic

ketoacidosis(DKA) . In blood β-hydrobutyric acid (βHBA) in blood is specifically measured both for diaganosis and ongoing monitoring of DKA(Sacks et al 2011).

HbA1c

International expert committee in 2009 established the role of HbA1c for the diagnosis of diabetes. It is the convenient test as it does not require fasting or timed samples and there is no effect of changes in diet or activity (Malkani&Mordes ; 2011). Further, it has also been described as biomarker in diabetes. Biomarker is defined as "a biological molecule found in blood, other body fluids, or tissue which represents a sign of a normal or abnormal process or of a condition or disease. these biomarkers help in identifying the people and also in adopting various preventive measures at subclinical stage (Lyons &Basu ; 2012) . it is now a days routine examination process may be due to its accuracy and convenience(Sacks et al 2011,Malkani&Mordes ; 2011). ADA has recommended that main aim of treatment of patient with diabetes should be maintaining the HbA1c at value <7%(53mmol/mol) and test should be performed atleast twice a year and quarterly for those patients whose therapy is either changed or do not meet treatment goals (Sacks et al 2011).

Treatment of Diabetes

The treatment of diabetes is basically managed by diet, hypoglycaemic drugs and insulin. Patients suffering from diabetes should follow proper diet plan so that energy intake is sufficient, which should include carbohydrates, fat and proteins with higher proportion of fat is higher as compared to other two categories. The conventional treatment of diabetes include oral hypoglycaemic drugs like sulphonylureas, bigunaides, alpha-glusidase inhibitors, thiazolidinediones etc. a recent treatment which is still under investigation is islet cell transplantation, but currently only whole organ(pancreas transplantation) can counted upon. Another way is transplantation of β-cells through stem cell, as these cells have ability to proliferate while maintaining its status and capacity to differentiate into specialised cells type. Further trans-differentiation is another method of β-cells replacement for diabetes therapy which involves gene transfer or growth factor(Dardano et al ; 2013, Van Belle et al 2013).

Exercises an Alternative to Improve Quality of Life in Diabetic Patients

Along with above mentioned treatment protocols patients with diabetes are advised to maintain their physical activity as much as they can in form of activities of daily living (ADL) or exercises (Lamonte et al ; 2012). Patients suffering from DM have low quality of life due to long term complications, social and financial burden, low glycaemia control and daily precautions to manage the disease (Polonsky ; 2002). Therefore there is a need to look for certain treatments protocols that help patients suffering from DM to improve quality of life and de-burden themselves. exercise training have positive effect on quality of life in patients with type 2 DM (Nicolucci et al ; 2011). Various studies have been done on evaluating the efficacy of exercises on quality of life but contrasting results have been obtained. Valerie H, Myers et al (2013) compared aerobic, resistance training and combination of both on quality of life and found that patients have improved physical quality of life from all three types of exercise protocols but no significant improvement was found in mental health quality of life . This study also indicated that patients with type 2 DM are benefited from exercise regimen rather than exercise modality (Myers et al ; 2013) as teiser et al used treadmill for 12 weeks and found no significant difference in quality of life (Tessier et al ; 2000). Also D.Robb Holton 2003 and Ajediran I Bello 2011 analysed the effect of exercise training on physiological factors and quality of life, apart from other parametes the quality of life did not singnificantly improve between the intervention and the control group (Holton et al ; 2003, Bello et al ; 2011). Therefore our view point is that this parameter needs an extensive study.

Exercices Helps in Increasing Strength in Diabetes Mellitus

Evidence suggests that patients suffering from diabetes mellitus have less muscular strength than people without type 2 DM (Hatef et al 2014), which further leads to reduced physical activity. AA Sayer et al 2005 demonstrated that known and newly diagnosed diabetic older men have significantly lower muscle strength and higher impaired physical functions than those without diabetes. This is supported by the fact that weaker muscles tend to be smaller

and therefore have potential for decreased glucose uptake and hyperglycaemia in blood(Sayyer et al ; 2005). However physical activities in form of aerobic/resistance or combination of both resulted in increae in strength in these individuals. Unaise Abdul Hameed 2014 examined role of resistance training and concluded that progressive resistance training of five resistive exercise at 65 % of 1 RM and progression after 4 weeks of training the improved muscle strength (Hameed et al.; 2012). A study done b Javier Ibanez, mickel Izquierdo, et al 2005 supportedthis conclusion. Theyevaluated the effect of twiceweekly for 4 weeks progressive resistance training 50%-80%of one RM. The resultsshowedsignificantimprovement in muscle strength(Ibanez et al ; 2005). American Diabetes Association (2000) and American College of Sports Medicine (2000) stated that combination of exercises i. e both strength as well as aerobic exercises should be incorporated in réhabilitation . Savvas P. Tokmakidis et al (2004) performed a study to examine the effect of combined strength and aerobic exercise, the aerobic training included walking / jogging on treadmill two times per week for 75 min along with warm up and cool down program, where as strength training included six resisance exercises which were perfomed in 3 sets with 12 repititionsatintensity of 60% of 1 RM. The exercise protocolresulted in better glycemic control, improved exercise tolerance and muscular strength (Tokmakidis et al ; 2004).

Exercises, Muscle Quality and Glucose

The muscle quality can be improved by exercises (Brooks et al ; 2007, Ivey et al ; 2000). Muscle quality refers to "maximal force production per unit of muscle mass of specific compartment may be a better indicator of muscle function rather than strength alone". Muscle mass and muscle quality are two different parameters they show no interdependence therefore deterioration of both depends on different reasons. Muscle quality decreases with age both in men and women, however it is evident from various studies that women have lower muscle quality as compared to men(Metter et al ; 1999).Seok Won Park (2006) conducted a study on community dwelling diabetic patients and evaluated hand grip and knee extensor strength and muscle quality. It was concluded that although muscle mass of patients with DM was greater in upper and lower limb when compared to non diabetic patients but muscle quality of diabetics was lower as compared to non diabetics (Park et al; 2006). Further exercises play important role in improving muscle quality and it is the predictor of health status and mortality. Naomi Brooks et al., 2007 stated that strength training given by them using pneumatic machines : upper back, chest press, leg press, knee extension and flexion , improved muscle quality and associated functional capacity derived from exercise interventions that further led to improved quality of life and improved disease outcome in people with diabetes mellitus (Brooks et al.; 2007).

Exercises play an important role in controlling blood glucose. It has become one of the ideal means of rehabilitation for patients with diabetes. Anything that increases the level of ADLs helps in controlling complication related to the disease(Boule et al.; 2001). Simple exercise like walking can be effective in regulating blood glucose levels. Tomas Fritz and urban Rosenqvist did a pilot study to determine immediate effects of walking on blood glucose levels in patients with type 2 diabetes. It was concluded that walking was helpful in reducing blood glucose levels and claimed that low intensity exercises are sufficient for acute reduction of glucose in elderly type 2 diabetics (Fritz & Rosenqvist; 2001). Effect of Exercise or physical activity depends on duration and intensity. When both these parameters increases there is increase in uptake of glucose by muscles and is balanced by hepatic glucose. Further moderate aerobic exercise also reduces risk of post exercise hypoglycaemia by decreasing plasma insulin levels(Colberg et al ; 2012)irrespective of sessions of exercises whether perfomed one time or multiple times (Baynardet al ; 2005). A study supporting this fact was performed by Subramanian SS and Venkatesan P (2012) reported that three sets of 10 exercises and 5 repetitions of each exercise per session, thrice a week for 12 weeks on stability ball was effective in lowering Body Mass Index and Glyclated haemoglobin (Subramaniam&Venkatesan; 2012). Various authors have undergone studies analysing effect of exercise be it aerobic, resistance or combination of both on blood glucose. Each reported fall in blood glucose and increase in uptake of glucose by muscles (Subramaniam & Venkatesan; 2012, Yardley et al.; 2013, Church et al ; 2010). Shivanandnayak and his co-workers (2005) reported

that in addition to drugs, diet control, walking for 50 minute on treadmill with 5 minutes of warm up and cool dowm sessions have a positive effect on level of glucose in blood (Nayak et al ; 2005). As obesity especially abdominal obesity is associated with insulin resistance, hyperinsulinaemia, hyperglycaemia and hypertension(Boule et al ; 2001).Therefore it is mandatory to not only reduce glucose levels but also body fat. Various studies now prove that abdominal fat or body weight cannot be reduced with just minimal rise in physical activity rather patients with type 2 DM have to undergo vigorous resistance training (Jackcic et al ; 2012, Jeffery et al ; 2003). Patient also need to undergo diet restrains combined with exercise protocols(Sigal et al ; 2006). Two randomised controlled trials done by Hwi Ryun Kwon and Kyung Ah Han et al (2010) concluded that moderate intensity walking for 60 min ,5 times per week for 12 weeks and resistance training using elastic bands of which strength equals to 40 to 50# of one repetition maximum for 3 days a week for 12 weeks are sufficient to reduce blood glucose and body fat (Kwon et al ; 2010).

Exercises Gait and Balance

A number of studies have been done on controlling glucose and decrease body weight by exercises. However very little work has been done on efficacy of exercises on rehabilitation of patient with diabetes facing problems like gait dysfunction, falls, balance problems. Elderly people, patients with diabetes or other degenerative changes faces balance and fall related problems(Sartor e al ; 2012, Kruse et al ; 2010, Fulk et al 2010). Balance being the key in the mobility and stability of the person, any kind of alteration leads to the fall related injuries(Najafi et al ; 2010). A very common complication associated with type 2 diabetes is peripheral neuropathy which leads to sensory and motor disturbances leading to impaired gait and balance (Allet et al ; 2012),postural instability, falls, depression, anxiety and decreased quality of life (Najafi et al ; 2010). Patients with diabetes have different gait as compared to those who are non-diabetics. A study performed by G.Yavuzer 2006 concluded that diabetes mellitus patients without peripheral neuropathy had significant gait deviations. Diabetics patients have slower walking speed, shorter step length, longer stance phase, wider BOS, great step time variability on irregular surfaces (Brach et al ; 2008, Yavuzer et al ; 2006, Petrofsky et al ; 2005). Other causative factors can be poor balance, neuropathies, and muscle weakness in combination or individually (Petrofsky et al ; 2005). Gait and balance of patients suffering from diabetes and diabetic peripheral neuropathy can be improved with exercises. Allet et al 2010 conducted randomised controlled trials on diabetic patients in which patient underwent training including gait and balance exercises, balance and endurance tasks alternated with functional strength and endurance exercises. The results confirmed that gait and balance can be concurrently improved by a targeted intervention (Allet et al ; 2012). Therefore patients with DPN should regularly take part in physical activities as exercises show decreased incidences of falls, loss of balance in these patients. All these problems that are associated with diabetes and DPN are seen in elderly and any other degenerative disorders therefore exercise regimens used for these can be successfully used to treat DPN. Although studies can be identified which illustrates the effect of exercises on balance, but to our knowledge there is a great need of various protocols and latest exercise tools and trends to be studied for the same. Therefore role of exercises on these parameters needs attention.

CONCLUSION

The present review enlists the efficacy of exercise program in diabetics. Exercises can become the parallel treatment along with the conventional treatment programs be it diet control or drugs. Lot of work has been done showing that exercises helps to control blood glucose levels. Physical activity of any type which requires muscular work more than the ADLs can help in lowering glucose in blood as lot of it is used by muscles during any externous physical activity. It would be advisable if patient is prescribed an exercise regimen instead of exercise modality, and these exercises being progressed time to time. Aerobic, resisted and combination of both can be chosen for patients with diabetes but various authors have proved that combination of aerobic and resistive exercises are beneficial when compared to aerobic and resistive exercises individually.

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