T.C.

YEDİTEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

MASTER'S PROGRAM IN PHYSIOTHERAPY AND REHABILITATION

EFFECTS OF RESISTIVE EXERCISE OR PROPRIOCEPTIVE EXERCISE TRAINING ON BALANCE AND SUPERFICIAL SENSE OF PATIENTS WITH TYPE 2 DIABETES MELLITUS

MASTER THESIS

GÜZİN KAYA AYTUTULDU, PT.

İSTANBUL-2017

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ADVISER

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İSTANBUL-2017

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ONAY

Bu tez Yeditepe Üniversitesi Lisansüstü Eğitim-Öğretim ve Sınav Yönetmeliğinin ilgili maddeleri uyarınca yukarıdaki jüri tarafından uygun görülmüş ve Enstitü Yönetim Kurulu'nun ..05./..05./..2017... tarih ve ..2017/08-10..... sayılı kararı ile onaylanmıştır.

Prof. Dr. Bayram YILMAZ
Sağlık Bilimleri Enstitüsü Müdürü

DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgement has been made in the text.

GÜZİN KAYA AYTUTULDU

DEDICATION

I would like to dedicate my husband İlhan AYTUTULDU and also I thank to my loving parents Gülcan KAYA and M.Fikret KAYA and my brother Hüseyin KAYA for their support.

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LIST OF SYMBOLS AND ABBREVIATIONS

Δ	post variables minus pre variables
6 MWT	6 Minute Walking Test
6 DYT	6 Dakika Yürüme Testi
AAE	Actual Angular Error
ADA	American Diabetes Association
ACSM	American College of Sports Medicine
AGP	Area Gap Percentage
AMI	Acute Myocardial Infarction
Anti GAD	anti glutamine acid decarboxylase
AP	Anteroposterior
ATS	American Thoracic Society
BMI	Body Mass Index
CGTI	Combined Glucose Tolerance Impairment
CVD	Cardiovascular Disease
DKA	Diabetic Ketoacidosis
DM	Diabetes Mellitus
GDM	Gestational Diabetes Mellitus
GLP-1A	Glucagon-like Peptide-1
GLUT 4	Glucose Transporter 4
HbA1c	Glycolated Hemoglobin

HC	Hip Circumference
HHS	Hyperosmolar Hyperglycemic State
HDL	High Density Lipoprotein
HRG	High Risk Group
IDDM	Insulin Dependent Diabetes Mellitus
IGT	Impaired Glucose Tolerance
IFG	Impaired Fasting Glucose
JPS	Joint Position Sense
LADA	Latent Autoimmune Diabetes of Adults
LDL	Low Density Lipoprotein
MS	Medspeed
ML	Mediolateral
MODY	Maturity Onset Diabetes of the Young
NDDG	National Diabetes Data Group
NIDDM	Non Insulin Dependent Diabetes Mellitus
OAD	Oral Antidiabetic Drugs
OGTT	Oral Glucose Tolerance Test
PG	Proprioceptive Exercise Training Group
PL	Perimeter Length
RG	Resistive Exercise Training Group
RM	Repetition Maximum
SPSS	Statistical Package f Social Science

TURDEP	Türkiye Endokrinoloji ve Metabolizma Derneği
T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
VO_{2max}	Maximum Aerobic Capacity
VPT	Vibration Perception Threshold
WC	Waist Circumference
WHR	Waist Hip Ratio
WHO	World Health Organization

ABSTRACT

Aytutuldu, K.G. (2017). Effects of Resistive Exercise or Proprioceptive Exercise Training on Balance and Superficial Sense of Patients with Type 2 Diabetes Mellitus, Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, Master Thesis. Istanbul.

The aim of the study is to investigate proprioceptive exercises training combined with aerobic exercises and resistive exercises training combined with aerobic exercises on dynamic balance and superficial sense. The study included 30 volunteers with Type 2 Diabetes Mellitus(T2DM) (24F, 6M; 51.23±7.68 years) who were referred to Fitness Center Arif Nihat Asya Kültür Merkezi Istanbul, Turkey by a medical doctor between December 2016- March 2017 and got diagnosed and followed up at least 6 month before. Glycemic control of all the participants were assessed according to fasting blood glucose and glycolated hemoglobin (HbA1c). Waist and hip circumference was recorded in centimeters. Six minute walking test (6MWT) was used to determine functional capacity of participants. We evaluated the dynamic balance of patients by Prokin PK200, Italy. Five parameters were obtained from Prokin as; Perimeter Length (PL), Area gap percentade (AGP) Medium Speed (MS), Anteroposterior equilibrium (AP) and Mediolateral equilibrium (ML). Proprioception assessment was done with angle reproduction test in direction of dorsiflexion and plantar flexion and deviations were recorded. Superficial sense was assessed with two point discrimination test and vibration threshold was evaluated by biothesiometer. Lower extremity muscles strength were assessed with handheld dynamometer (PowerTrack II commander, JTech Medical, Midvale, UT). The patients were randomly divided into Proprioceptive Exercise Training Group (PG) (n=15) and Resistive Exercise Training Group (RG) (n=15). All subjects were included exercise education program and both groups had trained aerobic exercise program for walking on treadmill (2times/wk. 6 week duration). The proprioceptive exercise program was applied in PG and the resistive exercise program was applied in RG twice a week and for duration 6 week. The main results of this study comparing two groups, PG showed greater improvement in vibration perception threshold values from the first and third metatarsal head of right foot and fifth metatarsal head of left foot.(respectively p=0.04, p=0.005, p=0.001). Consistent with

hypothesis, we found that proprioceptive exercises combined with aerobic exercise program was more effective to improve vibration sense and dynamic balance findings of people with T2DM compared to a program including resistive exercise combined with aerobic exercises

Key Words: aerobic exercise, dynamic balance, fasting blood glucose, functional capacity, HbA1c, muscle strength, proprioceptive exercises training, resistive exercise training, sensation, Type 2 Diabetes Mellitus, vibration threshold, waist and hip circumference.

ABSTRACT (Turkish)

Aytutuldu, K.G. (2017). Tip 2 Diyabetli Hastalarda Rezistif Egzersizveya Proprioseptif Egzersiz Eğitiminin Denge ve Yüzeysel Duyu Üzerine Etkileri. Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon ABD., Yüksek Lisans Tezi. İstanbul.

Bu çalışmanın amacı; Tip 2 diyabetli bireylerde aerobik egzersiz programına ek olarak verilen proprioseptif egzersiz eğitimi veya rezistif egzersiz eğitiminin denge ve ayak duyusu üzerine etkisini incelemektir. Çalışmaya Aralık 2016 - Mart 2017 tarihleri arasında Arif Nihat Asya Kültür Merkezi Spor Salonuna hekim tarafından yönlendirilen en az 6 ay önce Tip 2 diyabet tanısı almış, 30 (24K, 6E; 51.23±7.68 yıl) gönüllü dahil edildi. Katılımcıların glisemik kontrol değişkenleri, açlık kan şekeri ve glikolize hemoglobin (HbA1c) göre değerlendirildi. Bel ve kalça çevresi ölçümleri santimetre cinsinden kaydedildi. Fonksiyonel kapasiteyi belirlemek için altı dakika yürüme testi (6DYT) kullanıldı. Dinamik denge (PL, AGP, AP and ML sapma ve ortalama hız) değerlendirmesi Prokin PK 200, İtalya denge cihazı ile yapıldı Propriosepsiyon değerlendirmesi, açı reprodüksiyon testi ile dorsifleksiyon ve plantar fleksiyon yönde yapılarak sapmalar kaydedildi. İki nokta diskriminasyonu testi ile yüzeyel duyu değerlendirildi. Vibrasyon algı eşiği ise biyotezyometre cihazı ile ölçüldü.Alt ekstremite kas kuvveti, el dinamometresi (PowerTrack II commander, JTech Medical,Midvale, UT) kullanılarak değerlendirildi.Bireyler randomize olarak, proprioseptif egzersiz eğitimi grubu (PG) (n=15) ve rezistif egzersiz eğitimi grubu (RG) (n=15) olmak üzere iki gruba ayrıldı. Tüm bireyler egzersiz eğitim programına alındı ve her iki grupta öncelikle aerobik egzersiz (koşubandında yürüme, 2gün/hafta, 6hafta süreyle) programına dahil edildi. Propriosepif egzersiz eğitimi haftada 2 kez 6 hafta boyunca PG grubuna uygulanırkan, rezistif egzersiz eğitimi ise aynı sürede RG grubuna uygulandı. Gruplar karşılaştırıldığında; proprioseptif grupta sağ ayakta birinci ve üçüncü metatars başından ölçülen vibrasyon algı eşiği değerleri ile sol ayakta beşinci metatars başından ölçülen vibrasyon eşik algı değerlerinin azaldığı bulundu (sırasıyla p=0.04, p=0.005, p=0.001). Çalışmanın hipotezi ile uyumlu olarak, aerobik egzersizlerle kombine olarak verilen proprioseptif egzersizler, Tip 2 diyabet hastalarında ayak duyusunun ve dinamik

dengenin geliştirilmesinde rezistif egzersizlerle kombine olarak uygulanan aerobik egzersizlere göre daha etkilidir.

Anahtar Kelimeler: aerobik egzersizler, açlık kan şekeri dinamik denge, bel ve kalça çevresi, duyu, fonksiyonel kapasite, HbA1c, kas kuvveti, proprioseptif egzersiz eğitimi, rezistif egzersiz eğitimi, Type 2 Diyabet, vibrasyon eşik algısı.

1. INTRODUCTION AND PURPOSE

Diabetes mellitus (DM) is one of the most common endocrine diseases that is characterized by a disruption of intermediary metabolism due to insufficient insulin activity, insulin secretion, or both [1]. It is described by an elevation of fasting blood glucose depending on deficiency in insulin [2].

The present classification of DM consists of four categories. The type 1 DM changed by the prior treatment-based terminology that means insulin dependent diabetes mellitus(IDDM), also the type 2 one is changed by the non insulin dependent diabetes mellitus(NIDDM). The third group includes uncommon types of diabetes that are seen particular conditions or syndromes. The final group comprises the diabetes which can be recognized during pregnancy and it is named gestational diabetes (GDM) [3].

As regards the data of World Health Organization, the mortality rate of DM is 1-3% in European countries, 3% in United States and 2% in our country. According to TURDEP II (Türkiye Endokrinoloji ve Metabolizma Derneği) study data prevalence of Diabetes Mellitus in Turkey was 13.7 % in 2009-2010 [4]. The prevalence of diabetes in the world was 7.2% in 2013, the ratio is expected to be 8.7% in 2030[4]. Type 2 diabetes mellitus (T2DM) affects about 3% of the population or 100 million people worldwide [5]. The incidence of T2DM also rises with age, which may be related to decrease in exercise and muscle mass; but, as the incidence increases so T2DM is being found at younger ages [6].

Although diabetes is a common disease, its pathogenesis remains unclear, probably due to host of reasons. Perhaps the most important is the heterogeneity of type 2 diabetes because of an interplay between a variety of genetic and environmental factors [5].

Type 2 diabetes is directly associated with obesity and insulin resistance, and in developed countries, its incidence and prevalence has raised considerably [3]. Insulin resistance is caused by obesity, particularly visceral adiposity and physical inactivity. As a result of insulin resistance, people with diabetes have only a minor capacity to increase insulin secretion[6] and the insulin production becomes less sufficient level so the hyperglycemia is seen[3]. Macrovascular(arterial diseases and stroke) and microvascular (diabetic nephropathy, neuropathy, and retinopathy) complications are the adverse effects of hyperglycemia [7]. Also foot ulcers, amputation and autonomic nerve dysfunction may accompany with these complications [6].

Decreasing the incidence of microvascular and macrovascular complications is to success normal blood glucose levels by diet, lifestyle modifications (having regular exercises

behavior instead of sedentary lifestyle choice) and glucose lowering mediators for effective management of T2DM. The aim of the treatment is to prevent chronic complications depending on diabetes mellitus, and to remain blood glucose and blood pressure normal level [8].

Exercise is the most important cornerstone to prevent undesired effects of T2DM, it regulates the blood glucose level. Exercise has many benefits in addition to the glycemic control; improving aerobic capacity, increasing muscle strength, regulating body components and endothelial function [9]. Physical activity stabilizes the glucose production from the liver and causes glucose transition to active working muscles. In type 2 diabetes, blood glucose transport mechanism is disrupted to skeletal muscles with stimulating the insulin; the mechanism is not disrupted with stimulating muscle contraction.

The transport mechanism of blood glucose induced by muscle contractions is not affected while the transport mechanism of blood glucose stimulated with insulin to skeletal muscles is impaired; therefore blood glucose regulation is provided by exercise[8]. Further research is needed to investigate about the optimal exercise level for the maximum achievement of glycemic control. Recently the results of research suggested that the combination of aerobic and resistive exercise training (combined exercise) is more beneficial than a single exercise type [10]. While aerobic exercise affects improving insulin sensitivity, resistive exercises increase glucose transport to the muscle mass, and the two mechanisms synergistically work together [10].

Older people having Type 2 diabetes are more likely seen muscle weakness, gait and balance disorders, and have a higher risk of falling than non-diabetics. Considering the possible complications (peripheral neuropathy, autonomic dysfunctions, etc.) and using various medications, balance problems and falling risk are quite common. The exercise program for diabetes, should be arranged for improvement of balance and reduction of falling risk [11].

In this study, two combination exercises program which are included aerobic exercise and resistive exercises (RG), and aerobic exercise combined with proprioceptive exercises (PG) were used to determine the effects of balance and foot sensation among patients followed by Type 2 diabetes diagnosis. Therefore it was aimed to compare two different combined exercise program.

Two hypotheses identified in the study:

H0: The patients participating in the combined training (proprioceptive exercise training group) composed of aerobic exercise and proprioceptive exercises did not have more beneficial effects on balance and foot sensation of Type 2 diabetic patients than participating in the combined training (resistive exercise training group) consisting of aerobic exercise and resistive exercises

H1: The patients participating in the combined training (proprioceptive exercise training group) composed of aerobic exercise and proprioceptive exercises had more beneficial effects on balance and foot sensation of Type 2 diabetic patients than participating in the combined training (resistive exercise training group) consisting of aerobic exercise and resistive exercises

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1. Diabetes Mellitus

Diabetes mellitus is a metabolic disorder of several etiologies. It is characterized by disturbances of carbohydrate, fat and protein metabolism resulting from chronic hyperglycemia and defects of insulin secretion, insulin action or both[6]. Insulin is a kind hormone produced by the pancreas; when the body cells are using energy it is essential to transport glucose from the bloodstream into the body's cells. If the insulin secretion is ineffective, glucose remains circulating in the blood and it results high levels of glucose in the blood (known as hyperglycemia)[12]. The main clinical symptoms are polyuria, weight loss, thirst and blurring of vision and the symptoms depend on hyperglycemia [6]. If the hyperglycemia is out of the control, microvascular problems may be seen such as retinopathy, nephropathy, peripheral and autonomic neuropathy [13, 14] Diabetes may also cause macrovascular complications such as coronary heart disease, cerebrovascular problems, and peripheral arterial disease to appear earlier. Therefore, diabetes not only impact the quality of life adversely due to the complications, it can also reduce life span as well [15, 16].

2.2. History of Diabetes Mellitus

Diabetes is a condition of elevated blood glucose level which give rise to its main symptom of passing large amount of sweet-taste urine. The word meaning of Diabetes Mellitus is "*honey urine*" (*diabetes* from the Greek word meaning as the body acts as a conduit for the excess fluid and *mellitus* from the Greek or Latin for honey)[17]. The clinical features of diabetes mellitus were known from the antiquity. A polyuric state was discovered by Georg Ebers explained in an Egyptian papyrus dating from c.1550 BC. Aretaeus used to term "Diabetes" firstly in Cappadocia in the 2nd century AD. In the 5th -6th century Sushrut who was the Hindu physician recognized the sweetness of diabetic urine. Diabetes was neglected until the 17th century by British physician in Europe. Thomas Willis was discovered sweet taste of diabetic urine again. After about a century, Matthew Dobson (1735-84) who came from Liverpool noted that sweet urine originated from sugar. Therefore he described the hyperglycemia firstly in 1776. John Rollo added the name of "mellitus" on this disease [6, 17].

In the 19th century, Michel Chevreul (1786-1889) found that the sugar in urine was glucose[6]. Claude Bernard (1813-1878) clarified the glucose metabolism in France. Bernard found that blood glucose was obtained from glycogen in secretion of liver. In 1889, Oskar

Minkowski (1858-1931) and Joseph von Mering (1849-1908) stated in their experiments that pancreatic disorders were associated with diabetes but they did not continue their observations. Paul Langerhans (1847-88) defined the small cell islets of pancreas however, he could not construct the functions of the small cell islets. After that, Edouard Lagusse (1893) told that these Langerhans islets secreted glucose-lowering hormones and they were endocrine tissues[17].

Insulin was discovered by surgeon Frederick G. Banting, teaching assistant Charles H.Best, biochemist James B Collip and physiologist JJR Macleod at Toronto University in 1921. Elliot P Joslin (1869-1962) was one of the first doctors to have experiences. He was also initiative of first systematic education for diabetic patients [18].

2.3. Epidemiology of Diabetes Mellitus

Diabetes mellitus is one of the common chronic diseases and its increasing prevalence affects society. As of 2010, the prevalence of world diabetes in adults aged 20-79 was 6.4% to 285 million, it is estimated that diabetes will affect 439 million adults with an increase of %7.7. For developing countries, adult diabetes numbers are probably to increase by 69% compared to 20% for developed countries, from 2010 to 2030 [19]. Diabetes UK data reveals that 4.45% of the UK population had diabetes in 2011, equating to 2.9 million people and it is expected to grow 5 million people by 2025. There has been an explosive increase in the prevalence of diabetes with increasing urbanization which has now reached 8.0%, with 50 million people with type 2 diabetes in India. The prevalence of diabetes is estimated 9.7% in China, so diabetes has become a major public health problem [20]. According to the cross-sectional study (Türkiye Diyabet Epidemiyoloji Çalışması-TURDEP-I) which was done by Satman et al. in our country found that T2DM prevalence was %7.2, impaired glucose tolerance (IGT) %6.7. Based on these ratios, Turkey Statistical Foundation calculated that over 2.85 million diabetics live in our country according to 2007 population figures and 2.6 million people had impaired glucose tolerance(IGT) This study revealed the fact that %32 of diabetics were unaware of disease. In the recently published TURDEP-II study, 26,499 people over 20 years of age were examined nationwide, and the frequency of type 2 diabetes increased significantly in the past years and reached 13.7% [21]. Also it was found that diabetes was more frequent among women and those living in urban areas, and that the risk of diabetes was associated with aging, obesity, hypertension, lack of education, income level and habits. In a preliminary study demonstrated that the incidence of T1DM in

childhood(2.8/100.000/year) was relatively low in Turkey when compared to other countries [19].

2.4. Classification of Diabetes Mellitus

In 1979, for the first time, the National Diabetes Data Group (NDDG) made a broad classification of diabetes and then World Health Organization (WHO) made extensive classification of diabetes in 1985. WHO's classification was clinical and also termed diabetes as insulin-dependent (insulin-dependent diabetes mellitus (IDDM) and non-insulin dependent diabetes mellitus (NIDDM)[22, 23] The changes introduced by the ADA (American Diabetes Association) expert group in 1997 were reviewed by the WHO and the new diabetes classification was included in the WHO 2006 Consultation Report [24]. Type 1 Diabetes Mellitus (T1DM), Type 2 Diabetes Mellitus (T2DM), other specific types and gestational diabetes are the main forms of the new classification currently[6].

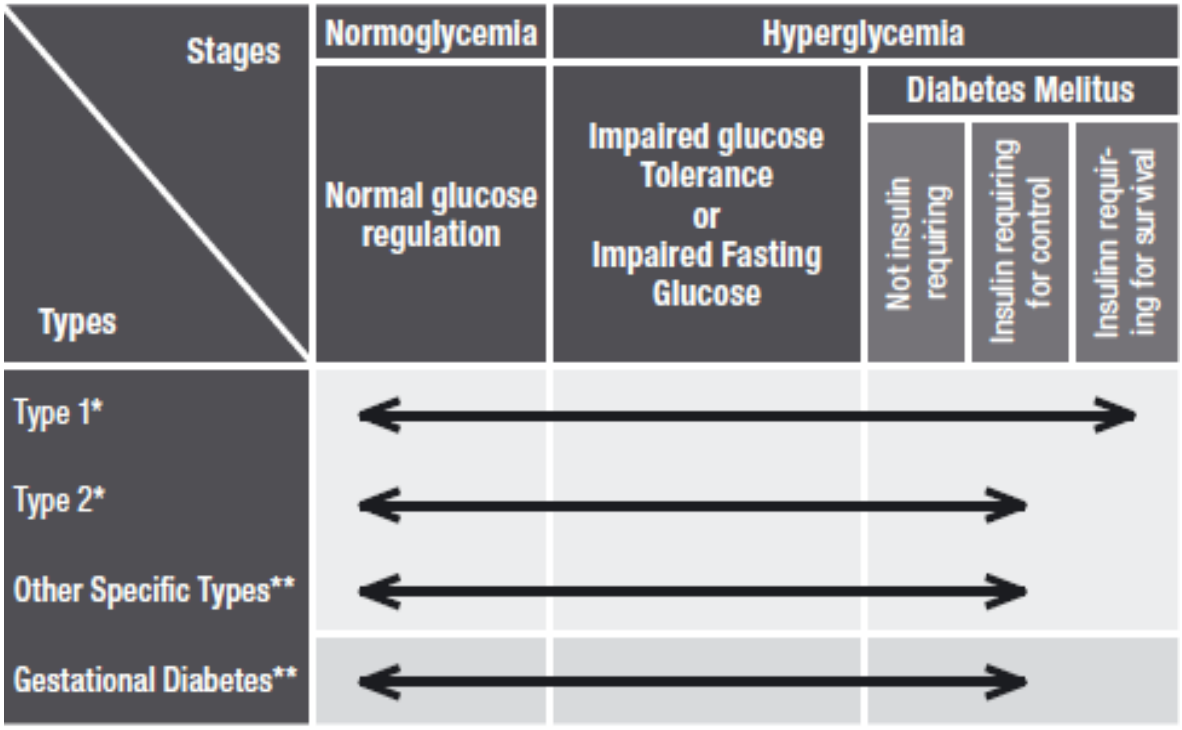


Figure 2.1. Classification Table [25].

2.4.1. Type 1 Diabetes Mellitus

5–10% of all cases are formed by this form of diabetes. It is concluded a progressive cellular-mediated autoimmune destruction of the pancreatic β-cells that produces insulin deficiency completely. β-cell destruction occurs rapidly in the majority especially in infants and children. The first manifestation of the disease is ketoacidosis and it is caused by sudden onset of β-cell failure [3]. In type 1 diabetes, generally autoimmunity with anti - glutamine acid decarboxylase (anti - GAD), anti - insulin and islet cell antibodies are detectable and cause β-cell destruction. Patients who have one or more of these antibodies can be divided subclasses of type 1 diabetes such as immune-mediated type 1 diabetes; Type 1A. However, Type 1 diabetes can occur without any auto-immune antibodies and auto-immune disease findings and this form of Type 1 diabetes resulting progressive hyperglycemia. It is named as idiopathic diabetes; Type 1B and patients need insulin to survive and for prevention of ketosis [18]. Typically young people with acute - onset T1DM, there is an older group with slower onset disease due to the residual β-cell function. They have an T2DM appearance because of diagnosing at the middle ages but have evidence of autoimmunity as evaluated by GAD antibody measurements and become insulin dependent at last. This is referred to as latent autoimmune diabetes of adults (LADA)[6]. These individuals may survive without needing insulin a few years after the detection of diabetes[18].

2.4.2. Gestastional Diabetes (GDM)

Gestational diabetes mellitus (GDM) is the form of diabetes that is detected during pregnancy firstly. It is seen 3-4% of all pregnancies. Symptoms are usually similar with type 2 diabetes. However, it is diagnosed before the symptoms are noticed during routine pregnancy screenings [23, 26, 27]. In 24th-28th weeks of pregnancy, screening tests are generally performed. Oral Glucose Tolerance Test(OGTT) of 75 or 100 gram is the diagnostic test of GDM. Insulin treatment is the another option unless the blood glucose level can be regulated with diet or exercise [27]. Gestational diabetes may lead to bad results for fetus and mother. Elevated fasting blood glucose before or during pregnancy may cause congenital anomalies and intrauterine fetal death in 4-8 weeks of gestation. Neonatal hypoglycemia, jaundice, polycythemia, hypocalcaemia are the other fatal complications may be seen in GDM. If the fasting plasma glucose level is above the 126 mg/dL or glucose level is above 200 mg/dL anytime it is the diagnosis of diabetes mellitus on pregnant [18].

2.4.3. Other Forms of Diabetes

The other factors which cause the diabetes can be genetic, pancreatic, metabolic or endocrine origin. The best definition of diabetes due to genetic reasons is maturity - onset diabetes of the young (MODY). It describes the diabetes occurring before the age of 25 with autosomal dominant heritance and generally non-insulin dependent. Unlike the T2DM characteristics, obesity and insulin resistance are uncommon but β-cell dysfunction is present [17]. MODY is a kind of disorder in which a mutation causes hyperglycemia by developing a defect in insulin secretion without any defects of insulin action. The other genetic disorder depends on a point mutation in mitochondrial DNA and it reveals the other form of diabetes which is seen with deafness. Autosomal dominant inherited genetic defects in the activity of insulin are available in some forms of diabetes rarely [18].

Abnormalities of the exocrine pancreas including pancreatitis, trauma and cystic fibrosis may cause diabetes. Also, several endocrinopathies are related with diabetes: Cushing syndrome, acromegaly which is increased insulin requirement and resulted in hyperglycemia [3]. Finally, viral infections also associated with β-cell destruction such as patients with congenital rubella. In addition to that, mumps, coxsackievirus B, cytomegalovirus, adenovirus may be considered to the cause of diabetes [28].

2.4.4. Type 2 Diabetes Mellitus

It is the most common metabolic disease in the adult population. 5-10% of all society have T2DM in developed countries. Although it is accepted as middle- advanced age disease , diabetes cases have begun to appear at younger ages in recent years [13].

T2DM is the most common form of diabetes and it is responsible for approximately 90% all of the diagnosed diabetic cases [3]. It is mainly characterized by the impairment of insulin secretion and activity. The etiopathogenesis of this form is still unclear, but β-cell destruction is absent in this form. In contrast to insulin insufficiency, insulin excess and insulin resistance are available in these patients. β-cell dysfunction improves because of the impaired insulin secretion. After the diagnosis of diabetes, glycemic control should be done for the patients regularly. Although the insulin level is high, blood glucose level cannot be held at the normal ranges due to the insulin resistance. Insulin treatment may not be needed to survive and insulin resistance may resolve with weight loss or pharmacological agents [18].

It cannot be diagnosed for many years because hyperglycemia occurs gradually and it may not demonstrate clinical signs for years. However the most common clinical symptoms are fatigue, polyuria, polydipsia, blurred vision, recurrent skin infection [20]. Most of patients

with T2DM are obese and obesity increases with the insulin resistance. The risk of developing the disease increase with age, obesity and physical inactivity. The presence of diabetic individuals in their family, obesity, hypertension and history of gestational diabetes mellitus in women increases the risk of T2DM.

The economic burden of diabetes on national health budgets is quite high because of the complications which is originated from micro and macroangiopathic changes. Loss of vision, kidney failure and foot amputations are the main microvascular complications. The risk of cardiovascular event is higher in patients with T2DM than non-diabetics. Mortality is caused by coronary artery disease in 75% of diabetics as well [13].

2.5. Etiology and Pathophysiology

The etiology of Type 2 DM is not exactly known but autoimmune β-cell dysfunction is seen in patients. Before the diagnosis of disease, depending on β-cell dysfunction impaired insulin and amilin secretion was observed with glucose stimulation. Most of the cases, the disease began many years before diagnosis and β-cell functional capacity was reduced substantially. People who have a family history of diabetes have 5-10 times more risk of Type 2 DM when compared to people without family history [18]. According to population-based studies, if one of the maternal twin has Type 2 DM, the probability of being found in the other twin is over the 90% [29].It has been confirmed that the genetic basis is associated with two allelic variants like transcription factor 7 [17]. The environment is also influence like genetics with the same proportion in terms of age of onset and severity of disease. In developing countries, especially in rural areas the incidence of Type 2 DM is generally low. The incidence is higher in western countries and westernized countries [29]. Physical inactivity, obesity and dietary factors may also contribute the risk of diabetes in a genetically predisposed individual [5]. The majority of Type 2 diabetics have insulin resistance, however most of these individuals with insulin resistance do not have diabetes. That is why the β-cells of these individuals compensate for insulin resistance by secreting more insulin. Type 2 diabetic patients with insulin resistance, there is a defect in β-cells in the response to compensate for insulin resistance. This defect is functionally manifested by a decrease in the first phase of the insulin secretion and the maximal insulin release phase induced by glucose. The increased secretion of insulin and the increase in the number of β-cells contribute the compensatory response of insulin resistance. Pancreatic β-cells hyperplasia is often seen in obesity and responsible from the exaggerated insulin response. Also ectopic fat accumulations

in islets, local inflammation induced by obesity, adipokines in local circulation and inflammatory cytokines may accelerate the β-cells loss. As β-cells failure progresses, glucose and free fatty acid levels begin to rise, this may lead to more β-cells toxicity. All these mechanisms lead to a reduction in progressive β-cells function which is specific for in type 2 DM [29].

2.6. Diagnostic Criteria

Diagnosis of diabetes is made by fasting plasma glucose, 2 hours oral glucose tolerance test (OGTT) and glycolated hemoglobin A1c (HbA1c) measurements [25]. These methods are described in detail below.

2.6.1. Measurement of Fasting Plasma Glucose

After at least 8 hours fasting, measuring the plasma glucose is the most widely accepted and cost-effective approach. If the fasting plasma glucose level is 126 mg/dL or high at least 2 times, diabetes mellitus is diagnosed [25].

2.6.2. Oral Glucose Tolerance Test

Measurement of oral glucose tolerance test is beneficial to diagnose diabetes in people with a high risk of diabetes. After 2 hours from drinking 75 g glucose liquid, if the blood glucose level is 200 mg/dL or high, diabetes is diagnosed [25].

2.6.3. Blood Glucose Level Measurement at Random

Diabetes mellitus is diagnosed if the measured plasma glucose level is 200 mg/dL or more at a random time in the presence of diabetes symptoms such as polyuric polydipsia [25].

2.6.4. HbA1c

It is a kind of measure that detects chronic glucose exposure is more probable to be informative than is a single measure of glucose when the presence of diabetes. The A1c assessment provides a dependable measure of chronic glycemia and associated with the risk of long term diabetes complications[25]. HbA1c≥ % 6.5 is the threshold value for diagnosing diabetes mellitus. Measurement of HbA1c does not need hunger. It does not vary in conditions such as acute disease and stress but is not as common as plasma glucose

measurement. The value is influenced by some causes such as blood loss, hemolysis, hemoglobinopathy, anemia[30].

The last diagnostic criteria published by American Diabetes Association (ADA) is seen in Table 2.1. for the diabetes and disorders of glucose metabolism[25].

Table 2.1.Diabetes and Pre diabetes Diagnostic Criteria

	Fasting Plasma Glucose	**OGTT 2 st PG**	**Random Plasma Glucose**	**HbA1c**
Normal	**<100 mg/dL**	**<140 mg/dL**		**%≤ 5.6 (≤ 38 mmol/mole)**
Pre diabetes				
IFG	100-125 mg/dL			
IGT	<100 mg/dL			
CGTI	100-125 mg/dL			
HRG				%5.7-6.4 (39-46 mmol/mole)
Diabetes Mellitus	≥ 126 mg/dl (7.0 mmol/l)	≥ 200 mg/dL	DM Symptoms(+) ≥ 200 mg/dL	% ≥ 6.5 (48 mmol/mole)

IFG: Impaired Fasting Glucose **OGTT:** Oral Glucose Tolerance Test **IGT:** Impaired Glucose Tolerance **CGTI:** Combined Glucose Tolerance Impairment **HRG:** High Risk Group

Diagnostic tests for diabetes are screening tests at the same time. Prediabetes can be detected in the early period by repeating these tests in risk groups. In studies, the prevalence of cardiovascular events was found to be lower in patients with prediabetes who started early treatment and risk factor modification [31]. If the screening tests results are normal, the repetitive test will be done 3 years later again. Diabetes risk groups was demonstrated in Table 2.1. People with one of / a few of these factors are considered to be at risk for T2DM [32].

Table 2.2.Criteria for Testing for Diabetes in Asymptomatic Adult Individuals

Testing should be considered in all adults who are overweight (BMI ≥ 25 kg/m^2)
*first-degree relative with diabetes *history of Cardiovascular Disease (CVD) *physical inactivity *women who delivered a baby weighing .9 lb or were diagnosed with GDM *HDL cholesterol level ,35 mg/dL (0.90 mmol/L) and/or a triglyceride level, 250 mg/dL (2.82 mmol/L) *women with polycystic ovarian syndrome *high-risk race/ethnicity *hypertension (140/90 mmHg or on therapy for hypertension) other clinical conditions associated with insulin resistance (e.g., severe obesity, acanthosis nigricans)
In the absence of the above criteria, testing for diabetes should begin at age 45 years.

Standarts of medical care in diabetes(ADA) [32].

2.7. Acute Hyperglycemic Syndromes: Diabetic Ketoacidosis, Hypoglycemia, Hyperosmolar Hyperglycemic State

Hypoglycemia occurs when the plasma glucose level is below 70 mg/dL. However it is stated that it is not only factor the threshold value for the hypoglycemia [26]. Iatrogenic hypoglycemia is seen in T2DM rarely but it is more common in patients using insulin. Hypoglycemia prevents to maintain glycemic control during time [33].

The most severe acute metabolic complications of uncontrolled diabetes mellitus are diabetic ketoacidosis(DKA) and hyperosmolar hyperglycemic state(HHS), they are also related with mortality[34]. HHS occurs when the relative insulin deficiency leads to hyperglycemia depending on the insulin requirement. This state causes dehydration and results in a severe hyperosmolar condition. DKA has similar metabolic abnormality but it results from absolute insulin deficiency and increased amounts of hormones. The insulin deficiency is accompanied by raised level of growth hormone, catecholamines will make the enzyme of lipase active which will lead to digestion of triglycerides and spread out fatty

acids[34]. The fatty acids are changed by the liver to ketone substances, they participate in circulation and leads to acidosis at the same time[18]. DKA is defined as three items; hyperglycemia (glucose> 250 mg/dL), ketosis and academia (pH<7.3) DKA and HHS are preventable diseases which is often caused by infection and insufficient insulin using. Patient education and prevention of fluid loss are cornerstones of treatment [18].

2.8. Complications of Diabetes Mellitus

The inability to control glucose metabolism disorders and to keep glycemia values within the desired limits leads to the development of chronic complications resulting in inadequacy in various organs[35]. These are microvascular complications such as retinopathy neuropathy, nephropathy and macrovascular complications such as cardiovascular, cerebrovascular, and peripheral vascular diseases. If there is no intervention, vision problems, lower extremity ulcerations and gangrenous, renal disorders may arise that may be resulted with early death [36].

2.8.1. Macrovascular Complications

Macrovascular complications are stroke, peripheral arterial diseases, fatal and non-fatal coronary arterial diseases. Atherosclerotic cardiovascular diseases (CVD) are 3-5 times more common in patients with diabetes than those without at any level of cholesterol and blood pressure. Atherosclerosis generally arises early in diabetics and progresses faster. Acute myocardial infarction and stroke results are worse in diabetics[17]. Heart contraction dysfunctions and diabetic cardiomyopathy may progress in diabetics due to the effects of CVD on myocardium and the rate of heart failure may be accelerated.CVD is the main cause for morbidity and mortality for diabetic patients [18].

Peripheral arterial disease (PAD) is characterized by the intermittent pain, ache and discomfort of lower extremity that may occur during walking but relieve with rest that is named by intermittent claudication. If the pain is caused by ischemia of the lower extremity at rest, suggesting insufficient blood flow through the legs[35]. PAD holds multiple vessels which are diffuse and narrowing distally in diabetics. It is generally occured in peripheral end arteries of patients with neuropathy or nephropathy and has risk for lower extremity amputations [17].

2.8.2. Microvascular Complications

The chronic effects of diabetes, the disease results in microvascular tissue complications (diabetic nephropathy, neuropathy, and retinopathy). As diabetes diagnosis year increases, the prevalence of complications may also increase and the prevalence is higher in patients with poor glycemic control [17].

2.8.2.1. Diabetic Retinopathy

Diabetic retinopathy is the most important cause of visual loss in adult population of developed countries. As a result of tractional retina detachment ,vitreous hemorrhage and macular edema caused by diabetes, vision loss may occur [37]. The possibility of diabetic retinopathy is related with both the duration and the level of hyperglycemia. It may be in forms of non-proliferative or proliferative and may be resulted with total or partial visual loss, vitrous hemorrhage, deterioration of retinal integrity, central vision loss and macular edema. Diabetic retinopathy is seen in 10% of individuals with insulin resistance, hypertension and high body mass index .The other conditions associated with retinopathy include early seen diabetes mellitus, smoking, insulin therapy, abnormal blood lipid (total cholesterol, LDL, HDL) levels, pregnancy, renal disease, high homocysteine levels and oil-rich diet intake [35, 37].

2.8.2.2 Diabetic Nephropathy

Diabetic nephropathy is the first reason of end stage renal failure in the whole world and related with increase of cardiovascular mortality [17]. It is defined that urinary albumin bar is positive constantly or more than 300 mg albumin excretion per day with the absence of other kidney disease in a diabetic patient. While in the early stages of diabetic nephropathy hyperglycemia is the primary factor that initiates the pathological process and in the late stage of disease, hypertension is accelerating this process. Hyperglycemia and arterial hypertension are two main risk factors; however, smoking, dyslipidaemia, proteinuria, glomerular filtration rate and genetic predisposition are also other risk factors of nephropathy [38]. It is recommended that the patients with T2DM should be scanned with regards to microalbuminuria from the diagnosis also, patients with T1DM should be scanned after an average of five year. In summary, tight glycemic control, inhibition of renin angiotensin system in early period and combined treatment options for blood pressure control can prevent to initiate diabetic nephropathy and end stage of renal failure [39].

2.8.2.3. Diabetic Neuropathy

Diabetic neuropathy is a disorder that occur in peripheral and autonomic nerves due to long term diabetes. Neuropathy develops 50-70% of diabetic patients. The most common symptoms are numbness, burning, tingling, pain and weakness in feet (and sometimes in hands). It depends on microvascular disease that feeds the neurons and motor, sensory or autonomic nerve fibers are involved, generally there was a axonal degeneration in this complication [40, 41]. Diabetic neuropathy has a lot of phenotypes but the most common type is a form of mild sensory disturbance distally and having minimal motor deficits. This group is 50% of all diabetic neuropathies. Distal thin fiber type neuropathy is also common and it is characterized by distal positive disturbances are together with both pain and heat sensorial impairment paradoxically. Pain is seen in most of neuropathy types, asymmetric neuropathies are different from the others, so the disease develops composition of immune-related mechanism and damages due to the compression. Although there are so many types of neuropathy, distal sensorial neuropathy is seen in all types [18] (Table 2.3). Diabetic polyneuropathy generates heterogenic clinical table with affecting proximal or distal sensory, motor or autonomic nerves differently. As a result of the thick fibers(A alfa and A beta) involvement; weakness, ataxia and reduction in vibration and position sense may be seen when the thin fibers (C fibers and A delta) involvement occurs; hyperesthesia, dysesthesia and decrease in heat sensation and autonomic dysfunction may develop [39]. Diabetics with painful neuropathy have dry and warm feet frequently due to the autonomic nerve involvement which leads to arteriovenous dilatation and lack of sweating. The reduction in sympathetic innervations exist and bone density is low due to the result of increase in blood flow and edema complication. Charcot arthropathy is the inflammation of joints, bone deformities may be associated with neuropathy. Foot ulceration is another possible complication that can be seen in these patients [17].

Table 2.3. Types of Neuropathies

Types of Neuropathies	
Symmetric Neuropathies	**Asymmetric Neuropathies**
**Distal sensorial neuropathy*	**Mononeuropathies*
**Sensorial neuropathy*	**Cranial neuropathy*
-Thick fiber types	**Radiculoplexus neuropathies*
-Thin fiber types	*radiculoneuropathy*
**Autonomic Neuropathy*	

2.8.2.4. Diabetic Foot

Diabetic foot is the most important cause of non-traumatic amputations [3]. 40-60 percent of non-traumatic lower extremity amputations depend on diabetes. The foot ulceration prevalence is 4-10% and incidence is 2.2-5.9% in DM. The incidence of amputation is 6-8 / 1000 per year [42]. Motor, sensory and autonomic neuropathy, ischemia often lead to diabetic foot ulcers and infections accompany with the ulcerations. Impaired foot posture is seen such as high arch, claw toes, pressure on metatarsal heads and heel due to the inappropriate shoes choice depending on loss of pain sensation. At these pressure points, the skin thickens and callus formation develops and the hemorrhage or necrosis in callus convert into ulceration[17]. The most important cause of foot problems the repetitive trauma were not recognized due to the loss of sensation and the problems were found in diabetics especially patients older than 40 years old [39]. 15-20% of diabetic patients deal with foot ulcer complication in a period of life. The risk of repetition of foot ulceration problems is common. All diabetic patients should be included in foot and nail care education program and foot examination should be necessary in every outpatient clinics [16].

2.8.2.4.1. Diabetic Foot Risk Factors

The main risk factors are neuropathy, trauma and peripheral arterial diseases in a diabetic foot. Infection may also accompany with these foot ulcerations. Good glycaemic control should be provided on a regular basis due to the influence of microvascular disease on diabetic foot. Because of the loss of sensation in feet, improper footwear using is another risk factor for injury. Smoking, poor eating habits, older age and low socio-economic status are the other risk factors for foot disease in DM [17].

2.8.2.4.2. Diabetic Foot Assessment

Neurological, vascular, dermatological and orthopedic evaluations should be done bilaterally. Sensory examination such as cold, vibratory sense and touch points must be tested. Semmes-Weistein monofilament test can be used to point out loss of protective sense at least eight area in foot. Tibial pulses should be noted for vascular evaluation and temperature, edema and skin features should be observed. Dermatological changes is also important to determine severity of infections and ulcers. In addition to these examinations foot deformities, muscle atrophies and prominent bone formations, claw or hammer toes must be examined and postural disorders should be recorded to find out suitable shoes [3, 43].

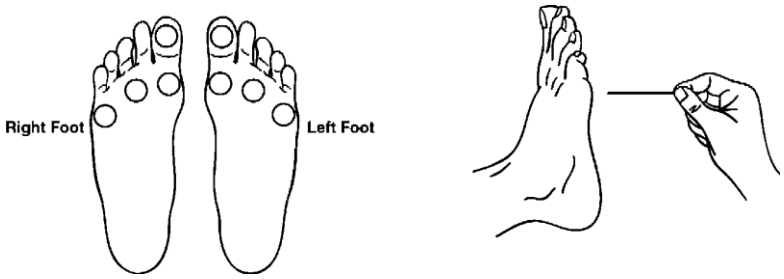


Figure 2.2. Main Assessment Areas in Foot [43].

2.8.2.4.3. Diabetic Foot Classification

Foot lesions were classified according to the Wagner classification.

Grade 0: Skin ulcerations are not present but high risk foot
Grade 1: Ulceration superficially in subcutaneuos tissue
Grade 2: Deep ulceration (may diffuse to joint capsule or tendon)
Grade 3: Osteomyelitis may be with abscess formation
Grade 4: Gangrenous of partial foot, lokalize gangren
Grade 5: Gangrenous of whole foot [44].

2.8.2.4.4. General Consideration of Diabetic Foot

The main pathogenetic mechanisms are ischemia, neuropathy and infection in diabetic foot disease; these factors may contribute the tissue necrosis, ulceration and gangrene. More than 80% of diabetic patients with foot lesions have neuropathy. Treatment is mainly focused on avoidance from lower extremity amputation. This goal is accomplished with three main ways; diagnosis the risky foot, treatment of acute foot disease and prevention of additional problems. All treatments are based on patient education about diabetic foot care. The effect of sensorial neuropathy and vascular insufficiency may decrease with regular follow-up, patient education and early intervention to existing foot lesions. Physicians and podiatrists are should take part in treatment with diabetic foot for protection of extremity and improvement the quality of life[18].

2.9. Related Disorders

2.9.1. Cardiovascular Morbidity

Cardiovascular Disease (CVD) and Acute Myocardial Infarction (AMI) is among the causes of death in diabetics and DM is an independent risk factor for these disease. It has been proven that diabetics have 2-3 times more risk for CVD than non-diabetic patients. Diabetes is also related with 1-2 times rise in mortality risk after AMI. After the 1 year of MI mortality rate is found considerably higher in diabetic patients. Metabolic risk factors such as hypertension, dyslipidemia, glucose intolerance also contribute the cardiovascular morbidity. Diabetes is associated with endothelial dysfunction, coagulopathy and formation of thrombosis and vasospasm developed by the additional adverse effect of hyperglycemia[5] There are a lot of molecular mechanisms which are mediating the co-development of DM and CVD. For example, TNF-α inhibits the insulin receptor signal and contributes the obesity-related insulin resistance. It is a proinflammatory molecule that is stimulating the atherothrombotic plaque and vascular reconstruction. The other independent factors that contributes the CVD and insulin resistance or DM are free fatty acids and C-reactive protein. Therefore, the increased causes of cardiovascular disease is associated with the co morbidity of other factors in DM[18].

2.9.2. Insulin Resistance and Metabolic Syndrome

Reaven defined the insulin resistance as "the clinically significant relationship between cardiovascular risk factors, insulin resistance and obesity" in 1988. Insulin resistance may describe with the impairment of the effect of insulin and insufficient insulin response. The resistance is not same in different tissues. For instance, insulin mediated glucose consumption decrease in muscle cells so lead to high blood glucose level. In liver hepatic glucose production is facilitated by the reduction in insulin level. In fat tissue, lipolysis is stimulated and free fatty acids occurs and they have serious adverse effects such as lipotoxicity and glucose toxicity[5].

The definition is changed with "metabolic syndrome" at National Cholesterol Education Program meeting in 2001. According to results of the meeting, it is shown that at least three criteria out of five criteria is required for diagnosis;

- Rise in fasting plasma glucose level(>110 mg/dL)

- HDL Cholesterol (for men<40 mg/dL, for women <50 mg/dL)

-hypertension (>130/85 mmHg)

-hypertriglyceridemia (>150 mg/dL)

-visceral obesity (for women >88 cm for men >102 cm) [18].

As a consequence of obesity and metabolic syndrome, sympathetic nerve system responses decrease against the sympathetic stimulus (hypoglycemia, postural changes, caffeine, alcohol, and smoking). Weight loss and exercise provide the regulation of sympathetic stimulus and play an important role for the treatment of metabolic syndrome[45].

2.9.3. Obesity

Obesity is a significant public health problem worldwide and it is associated with energy imbalance. Severe obesity is common in industrial societies nowadays. (BMI ≥40 kg/m^2) The balance between caloric intake and energy consumption is disturbed. Insufficient physical activity has an important effect on epidemiology of obesity[46, 47]. It was reported that the genetic predisposition and environmental factors are related with the obesity etiology [5].

Obesity may also define with the chronic fat accumulation or excess energy storage. Body mass index (BMI) is used for classification of obesity practically. It is calculated the proportion of body weight to body height in meters. The BMI interval of 25-29.9 kg/m^2 is defined as overweight. 30-34.9 kg/m^2 of BMI is the first level of obesity and the 35-39.9 kg/m^2 is the second level, and over 40 kg/m^2 is the most serious and third level of obesity[5].

Obesity means the excessive storage of triglyceride in adipose tissue, excess fat mass with increasing in body weight. The World Health Organization (WHO) was defined that abnormal increase in fat tissue or excess fat accumulation. WHO was pointed out that obesity is complex and multifactorial disease and it is characterized by endocrinal, metabolic and behavioral changes[48, 49] The fat tissue accumulation leads to impairment in glucose and lipid mechanism and cell metabolism damages such as insulin resistance. Increase amount of cytokine releasing contributes the hypertension and dyslipidaemia[46]. Although the effect of obesity on T2DM and insulin resistance was not defined yet, the fatty tissue is likely to be

related to substances that leads to insulin effect impairment by acting on the liver or muscle. The relationship was found between obesity and hyperinsulinemia, it may cause the insulin resistance [18].

2.10. Glycemic Goal

Glycemic targets should be determined individually. Blood sugar level should be kept between the 80-120 mg/dL (4.4 ve 6.7 mmol/L) in daytime and between the 100-140 mg/dL (5.6-7.8 mmol/L) at night and HbA1c level should be under the 7% for glycemic control. The target may be changeable in geriatrics and patients with frequent hypoglycemic attacks[13]. Poor glycemic control and insulin resistance lead to autonomic neuropathies, hemodynamic problems and increase in peripheral sympathetic nerve system activation. Low A1c values significantly prevent the rate of development of microvascular complications [18]. Only a one percent of reduction in HbA1c level means that risk of cardiovascular events are reduced by 15-20%, microvascular complications are reduced by 37% [50].

2.11. Management of Type 2 Diabetes Mellitus

The main purposes in effective treatment are improvement of glycemic control, weight loss for obese patients and decrease the cardiovascular risk factors such as hypertension, dyslipidemia which are responsible from 70-80% of deaths in diabetic patients. The initiation of treatment is lifestyle modification and major steps are increase diet and exercise or smoking cessation. Weight loss is provided with increasing physical activity and decreasing total energy intake. At least 4 kg weight loss is required for hyperglycemia control and slow weight loss is recommended [17]. Patient education is an essential factor for patients with chronic disease and provides them to recognize the complications of DM and develop self-care techniques. The skills are required for the life of patient include the following as; self monitoring of blood glucose, oral anti diabetic agents or insulin applications, appropriate food consumption, hypoglycemia treatment and exercise dosage [18].

2.11.1. Pharmacological Treatment

Pharmacological treatment may be given when the lifestyle modification is not sufficient for patient's glycemic control. If the initial glucose level is not above the 350 mg/dL oral anti diabetic treatment may be decided after the nutritional therapy trial. The 4-12 weeks of diet or lifestyle modification were reasonable and if the fasting blood glucose level is above

the 140 mg/dL oral pharmacologic agents should be initiated to use [18]. The patient should be checked after 3 months later at each treatment changes. The first choice should be metformine in the first step of treatment and sulfonylurea, glinide or alpha glucosidase inhibitor may be given for patients with obvious hyperglycemia. Sulfonylurea should be added to metformine in the second step of treatment and other Oral Anti-diabetic Drugs (OADs) may be given in the second step. The third step treatment may be initiated with basal insulin (if necessary, premixed insulin) or an extra OAD or glucagon-like peptide 1(GLP-1A) preferably. Insulin must be initiated in the fourth step of treatment absolutely, if a patient have already used insulin, the treatment should be intensified. If there is no contraindication metformine should be continued with insulin [51].

2.11.2. Dietary Therapy

The aim of diet treatment is to protect ideal body weight, to keep glucose and lipid levels in normal values prevention of complications and improvement the quality of life. Generally all diabetics should be fed with foods which are including low density fat, medium carbohydrate and preferably whole grain and high fiber content[13]. Patients with T2DM should be supported to rise physical activity level and to decrease saturated and Trans fats, cholesterol and sodium intake for glycemic improvement. The nutrient intake may be modified according to lifestyle and chronic complications of diabetes can be reduced. Low-carbohydrate diets that keep daily carbohydrate intake below 130 g is not recommended for patients. The healthy nutrition model should be included in carbohydrate foods such as full grain cereals, fruit, vegetables and low-fat milk. Sugar and sugary drinks consumption should not be limited due to reduce risk for weight gain and worsening of cardiometabolic risk. For individuals who only use diet treatment or OAD with diet or insulin together; diet, carbohydrate intake should be divided to meal and snacks and should be in similar amounts should not be changed from day to day [51].

2.11.3. Exercise Therapy

Physical activity or exercise is one the fundamental element in the management of diabetes mellitus. Exercise treatment is an essential with the diet and pharmacological agents to decrease cardiovascular risk factors and to regulate glycemic control. It is shown that the regular physical activity provides glycemic control, decrease in insulin resistance. In addition to that, exercise is an important part of weight-reducing diets and provides the loss of adipose

tissue and regular distribution of the remaining fat tissue[18]. Exercise should be consisted with physical condition and lifestyle. The 30-60 minute daily walk can be part of moderate exercise basically. In contrast to Type 1 DM, exercise does not cause hypoglycemia in Type 2 DM. Resistive exercise may have more benefits in addition to aerobic exercise, but it should be done regularly and be increased progressively, it should be begun with a low intensity workload. Exercise education adjusts the normal blood glucose level, decreases cardiovascular risk factors and when compared to patients with poor cardiovascular fitness, exercise decreases the long term mortality by 50-60%[17]. American Diabetes Association recommended that, 75-85% of one repetition maximum 8-10 repeats and 3 sets resistive exercise was beneficial in addition to aerobic exercise[8]. The important effects of exercise were to improve aerobic capacity and increase muscle strength, therefore it provides regulation of body composition. Well-programmed exercise provided safe and effective results for patients. Frequency and type of exercise are the determining factors of patients-specific exercise program. Diabetic patients who exercise regularly can have the opportunity to reduce or even discontinue the dosage of insulin. In addition, exercise decrease low-density lipoprotein level (LDL), triglycerides and blood pressure, and increases high-density lipoprotein (HDL) levels [52].

2.11.3.1. Benefits of Exercise Training

The potential benefits of exercise for health of type 2 diabetic patients are improvement insulin sensitivity to glucose level, blood pressure and blood lipid profile. Insulin-stimulated glucose transporter 4 (GLUT4) translocation is generally impaired in T2DM. The increase in glucose used by working skeletal muscles provides insulin sensitivity. Peripheral glucose uptake occurs with increase in GLUT4 glucose carriers. Exercise training is the most potent stimulus to increase skeletal muscle GLUT4 expression, an effect that may partly contribute to improved insulin action and glucose disposal and enhanced muscle glycogen storage following exercise training in health and disease [53]. Unfortunately, if the exercises are not continued, these effects will be lost. Recent studies demonstrated that exercise was beneficial to decrease hemoglobin A1c level and it provided long term glycemic control [18]. Exercise stimulates to increase enzymes and glycogen synthesis, thus reduces the circulating glucose in blood. Also, type IIa muscle fibers have more glucose transporters and insulin sensitive, alteration of type IIa muscle fibers to type IIb muscle fibers rise with regular exercise. Resistive training programs contribute to increase in muscle mass so, visceral adiposity and muscular fat stores reduce[3]. Muscle contraction accelerates blood glucose

uptake to skeletal muscles and depletion of muscle glycogen. After the glycogen stores utilization, adipose tissue begins to be used to form of free fatty acids. Appropriate physical activity program may help to weight loss and related with lower cardiovascular risk and mortality rate. Weight loss have beneficial effects to decrease inflammatory cytokines and renal function. Exercise can be used for different symptoms of T2DM and have positive results such as peripheral neuropathy, peripheral vascular disease , increased falling risk, cognitive disorders, mobility impairments [9]. On the other hand, the rate of increase in the incidence of depression in Type 2 DM is associated with poor glucose control, it may be resolved with behavioral changes in sedentary population so the exercise habits may be effective on this problem. As a conclusion, regular exercise was the cornerstone of diabetes management for increasing quality of life [54].

2.11.3.2. Exercise Prescription

Pre-exercise evaluation should be done before the exercise program prescription. All patients are recommended with undergo a detailed history, physical examination and observation of microvascular and macrovascular complications of T2DM. Cardiovascular risk factors should be assessed with exercise stress testing especially higher risk diabetic patients such as patients with cigarette smoking, hypertension, dyslipidemia, retinopathy and nephropathy complications. After the comprehensive evaluations are completed, exercise program is prescribed safely[8]. Exercise program should be prepared individually considering the personal characteristics and medical features. The risks for patient's condition and expected outcome determines the type, intensity and duration of exercise. Aerobic exercises is recommended with three or five times a week on non-consecutive days and 40%-60% of maximal aerobic capacity (VO_{2max}) is appropriate for moderate-intensity exercise. The American College of Sports Medicine (ACSM) guidelines advised the 150 min moderate exercise or 75 min vigorous exercise at least three days a week. Additionally resistive training may be performed with involving upper, lower body muscles and core muscles at 50% of 1-repetition maximum(RM) intensity, 5-10 repetitions and three or four sets[55]. Elastic resistance bands, dumbbells or free weights can be used for optimal resistance and can be progressed 75%- 80% of 1 RM 8-10 repetitions of each set. Supervised training is essential to determine optimal weight and effective blood glucose control also reduction of injury risk. Stretching may be useful to decrease musculoskeletal injuries and increase muscular flexibility and range of motion in joints pre-exercise and post-exercise. Many studies have

indicated that combined aerobic and resistive training is more beneficial than resistive or aerobic exercise alone. Yoga tai chi is other preferable mild exercises may help control of blood glucose[8].

2.11.3.3. Precautions to Prevent Adverse Effects

Exercise has great benefits for diabetic patients but also have some risks. One of these risks is hypoglycemia which occurs during physical activity. In order to avoid hypoglycemia, doses of medicines used by patients should be reduced in accordance with the influence of exercise on blood glucose and carbohydrate taking should be done if the blood glucose is below the 100 mg/dL during or prior to exercise. Another complication that can be seen is ketosis or hyperglycemia during exercise. If the blood glucose is greater than 250 mg/dL, ketones may be available in blood due to the destruction of fat tissue. To avoid this, exercise should be delayed and insulin requirement should be provided[56]. Pre-exercise and post-exercise blood glucose levels should be measured, glycemic status and medication use should be followed. Therefore food intake, regular clinical follow-up, and regulation of insulin intake is important before starting the exercise program[57, 58].

2.12. Exercises Types

2.12.1. Stretching Exercises

Flexibility exercises must be absolutely included the exercise program due to the increase the range of motion and decrease risk of injury[59]. Especially, in patients with type 2 diabetes, the structural changes in the joints are available and joint movement limitations may occur. Diabetic ulcers is caused by the high plantar stress in ankle deformities and presence of neuropathy. The other benefit of stretching is to distribute the high plantar pressure in foot and decrease the ulceration risk[60]. Active joint movement exercises, strengthening the agonist-antagonist muscles and stretching exercises may be applied together to improve flexibility so the stretching should be complementary to other types of exercise[59].

2.12.2. Callisthenic Exercises

Calisthenics are appropriate dynamic exercises for older and sedentary individuals. It can be adapted according to the cardiovascular level of subjects'. Calisthenics include rhythmic, enjoyable, simple movements and muscle strength, flexibility are increased by

them. They are performed with a group or alone using the body's own weight as resistance. Besides the cardiovascular and muscular endurance benefits, callisthenic exercises provides the balance agility and coordination[61]. Also these exercises have psychosocial benefits such as increase in hand skill, responsibility sense, teamwork and competitive excitement. They help to keep healthy posture, muscle strength, aerobic performance and normal joint range of motion[62].

2.12.3. Aerobic Exercises

Aerobic exercises such as walking, running, swimming should be preferred in diabetics more extensively. It is recommended for sedentary diabetics due to the benefits of glycemic control and insulin sensitivity. Aerobic exercise can also reduce cardiovascular disease risk and other microvascular complications and improve lipid control, blood pressure and body weight control but the it remains uncertain which intensity and duration will be most efficient for obese and T2DM patients[63]. At least 150 minutes moderate aerobic physical activity per week is required with calorie restriction for individuals with diabetes and pre-diabetes to lose weight[51]. Aerobic exercises should be done at moderate intensity which means 40%-60% of maximal oxygen consumption[8]. Patients with Type 2 diabetes have poor aerobic capacity, low muscular strength and flexibility due to the fact that, regular exercise is obligation for them. It was shown that physically active diabetics have good aerobic capacity, muscular strength and better prognosis than others[64]. Aerobic exercise program is applied with lifestyle modification in diabetic patients. It is preferred due to the excessive sympathetic activity stimulation effects, hypoglycemic effects and ability to decrease insulin resistance. Aerobic, resistive and flexibility exercise should be combined, because the metabolic effects on body composition are complementary[65].

2.12.4. Strengthening Exercises

Resistance or strength training increase muscle mass and resting metabolic rate and decrease fatty mass in body. Strengthening exercises affect body composition positively, decrease risk of disease and especially abdominal fat tissue. The other benefit is improvement of bone health with increasing bone mineral density. Resistive and cardiovascular exercises helps to deal with osteoporosis and insulin sensitivity is also improved by resistive exercises. They increase stabilization and reduce falls, injury so have beneficial effects on balance etc. factors[49]. Exercises may perform with resistance bands, free weights, weight machines or

self-weight of body. Muscle endurance, muscle strength and functional capacity is raised with regular resistance training. After training, glycemic control is provided with increasing glucose transporter-4 level, glycogen synthesis is activated so insulin resistance decreases respectively. The exercise program should be initiated lower level and progressed gradually to avoid injury. The recent studies were shown that combination of aerobic and resistive exercise training is the most beneficial training for patients with T2DM and more positive effects than a single exercise type[11].

2.12.5. Proprioceptive Exercise

Older patients with T2DM generally deal with balance problems due to poor glycemic control in addition to normal aging process. Gait alterations and balance impairment and proprioceptive deficits are available in diabetics. Reduction of lower extremity muscle strength, inadequate sensorial information and lower gait velocity are contributing factors that increase risk of falling[66]. Crews et al. was demonstrated that the incidence of falls was found 39% in elderly people with DM annually and also a relationship between DM and falls was found in their study[67]. Medication use and diabetic neuropathy are other factors that lead to instability. Physical inactivity cause fear of falling, functional dependence and reduced mobility. Exercise program are proposed to improve balance, gait and decrease falling risk. There is a few studies is found in the literature that using proprioceptive and balance exercise directly. However, Morrison et al were shown in their study the resistance and balance training was beneficial for balance, proprioceptive and strength of lower limb muscles regardless the presence of neuropathy.

There are many studies about the effects of aerobic, resistive and combined exercises on patients with T2DM, but it has not been shown which exercise protocol is more effective. Also there is a gap in the literature regarding how to optimize adequate exercise type and intensity to achieve maximal enhancements. Considering the inadequacy of this literature, we aimed to compare two different combined exercise program. Two combination exercises program which are included aerobic exercise and resistive exercises (resistive exercise training group (RG)) and aerobic exercise combined with proprioceptive exercises (proprioceptive exercise training group (PG)) were used to determine the effects of foot sensation and balance among patients followed by Type 2 diabetes diagnosis.

3. MATERIAL AND METHOD

3.1. Subjects

The sample of study consists of patients with Type 2 Diabetes Mellitus (DM) got diagnosed at least 6 months and who referred to Fitness Center in Pendik Arif Nihat Asya Kültür Merkezi Istanbul Turkey by a medical doctor between December 2016- March 2017.

The study included in 30 patients (24F, 6M) with T2DM.The patients who met inclusion criteria are divided into two groups. According to simple randomization method, patients which have odd survey numbers with Type 2 DM involved to the aerobic exercise and proprioceptive exercise training group (PG) and the patients with even survey numbers are involved to the aerobic exercise and resistive exercise training group (RG).

3.1.1. Inclusion Criteria

- Participating to the study in a voluntary basis
- Patients with 30-60 years old
- Getting diagnosed with Type 2 Diabetes Mellitus (DM) at least 6 months.

3.1.2. Exclusion Criteria

- Unstable cardiac condition
- Uncontrolled Diabetes Mellitus
- Uncontrolled Hypertension
- Symptomatic Heart Failure, unstable angina
- Peripheral Arterial Occlusive Disease
- Diabetic foot ulcers
- Part/total foot amputation
- Myocardial infarction within 3 months prior to study
- Coronary Artery Bypass within 3 months prior to study
- Cerebrovascular ischemia/stroke (including TIA) within 3 months of study
- Severe retinopathy, nephropathy
- Thyroid Dysfunctions (hyperthyroidism, hypothyroidism).

The study protocol was approved by the Bahçeşehir Üniversitesi Ethical Committee at the date of 07.12.2016 and issue number was 10/04 (Appendix 2). Participants involved in the

study on a voluntary basis. The aim and plan was explained and informed written consent was obtained from each patient (Appendix 1).

3.1.3. Flow of Research

We planned to have 33 Type 2 diabetic patient for PG and RG who satisfied interventions. As for the first step, we separated the participants according to survey numbers. While the participants with odd survey number involved the proprioceptive exercise training group (n=17) and the participants with the even survey number involved the resistive exercise training group (n=16).

After the end of first assessment 6 weeks exercise training program initiated with 33 participants. However, three individuals were excluded from the study due to various reasons and they did not complete the exercise program (Figure 1. Flowchart Diagram)

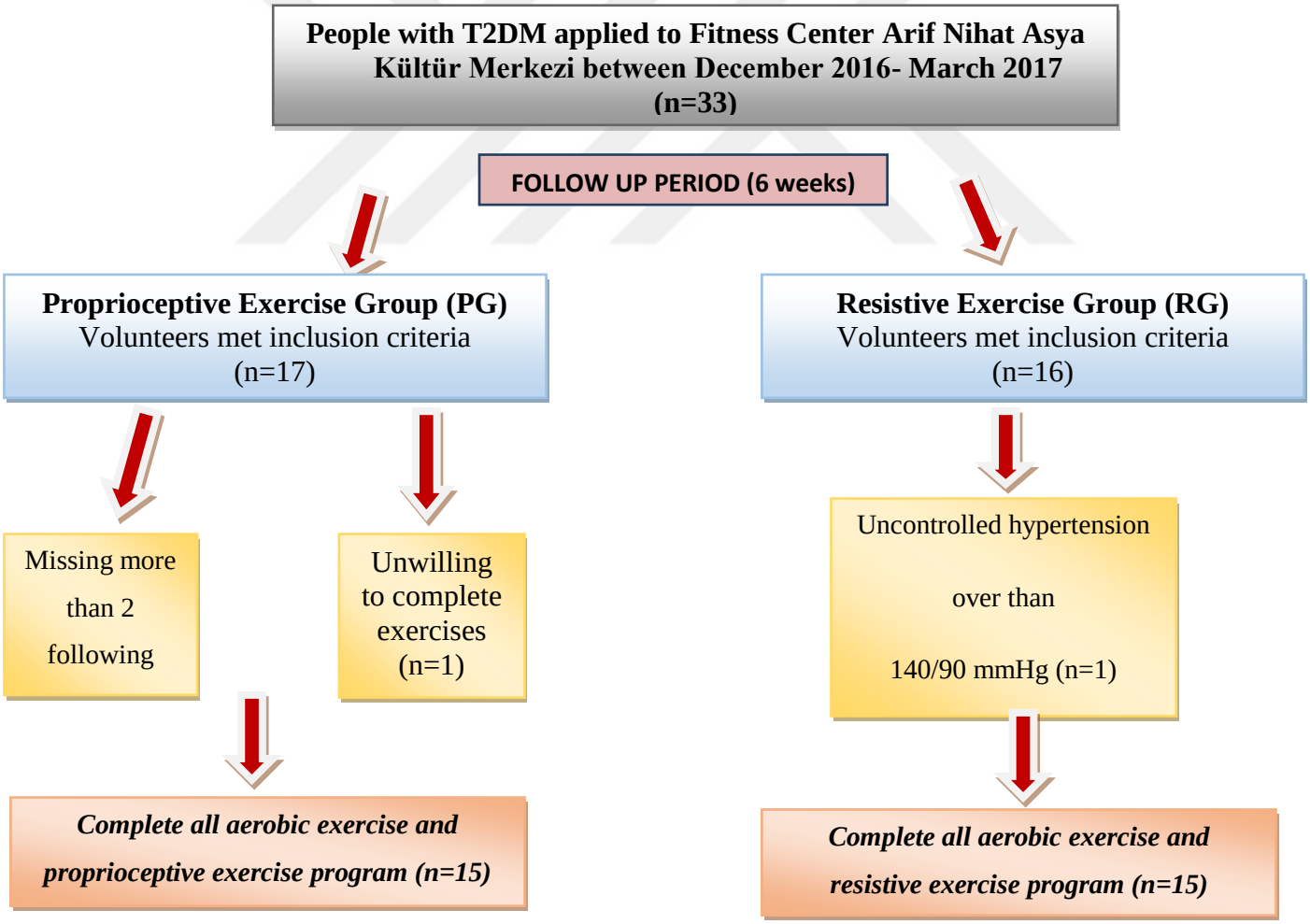


Figure 3.1.Flowchart Diagram

3.1.4. Study Protocol

All subjects were included aerobic exercise program which is prepared the according to criteria of American College of Sports Medicine (ACSM) Evidence and American Diabetes Association (ADA) Clinical Practice Recommendation Statements[8]. Patients were given instructions for their diet program by a dietitian and were also reviewed for standard medical care by their physician. The aerobic exercise program consists of 5 minutes warm up period and after that 30 minutes treadmill walking at %60-75 of Maximum Heart Rate, with the rest intervals and finally 5 minutes cool down period. The aerobic training program was done twice a week in a clinic with a supervisor physiotherapist for a duration 6 week.

Additionally, proprioceptive exercise group (PG) participated in proprioceptive exercise program combine with aerobic exercise program as described above. The proprioceptive training program was applied by physiotherapist under the supervision in the clinic twice a week. It consists of applying the pressure the soles of feet with serrated sensory massage ball, ankle pump exercises, tandem walking, sit to stand exercise, toe rising, drawing "8" exercises without visual information and weight bearing exercises on bosu trainer. Additionally, these exercises was performed per a day/3 days at home a week for a duration 6 week. The resistive exercise group (RG) participated in resistive exercise program that consisted of ankle dorsiflexion, plantar flexion, inversion and eversion; knee flexion, extension exercises with green theraband in the sitting position and hip flexion, extension, abduction, adduction exercises with the same theraband in standing position. Each exercise was done 8 repetitions and three sets. Also, these exercises were given home exercise program one day a week.

Table 3.1.Interventions of Proprioceptive Exercise Group and Resistive Exercise Group

Proprioceptive Exercise Group (PG)	Resistive Exercise Group (RG)
Exercise Education Program	Exercise Education Program
Aerobic Exercise Program 2 days/week at clinic for the duration 6 week	Aerobic Exercise Program 2 days/week at clinic for the duration 6 week
Proprioceptive Training Program 2days/week at clinic+ 1 days at home	Resistive Training Program 2 days/week at clinic+ 1 days at home

3.2. Evaluation

3.2.1. Structured Questionnaire for Patient's Demographic Characteristics

The structured questionnaire prepared by researchers applied face to face interviews. The questionnaire included age, gender, education level, occupation, marital status, income level and health insurance to understand socio-demographic conditions of volunteers. The second part of questionnaire was about their exercise behaviors, smoking habits, taking medications, having chronic diseases (APPENDIX 2).

3.2.2. Assessment of Glycemic Control Variables

At the beginning of the study, HbA1c level and fasting blood glucose level were evaluated for metabolic control with patient's routine controls in their clinics follow-up. At the end of the study, these metabolic variables was evaluated again in order to observe changes.

3.2.3. Anthropometric Measurements

Waist circumference (WC) is a kind of anthropometric measure of visceral adipose tissue distribution. The visceral adipose tissue accumulation represents the undesirable factors for metabolic diseases such as dyslipidemia, hypertension and diabetes mellitus. It is defined as defensive mechanism of metabolic disease and commonly came close to hip circumference (HC)[68].

Waist circumference was measured in centimeters without compression of the soft tissue at midway level between lower rib margin and iliac crest by using no stretchable measuring tape. The hip circumference was also measured in centimeters using the same measuring tape at its widest portion of the buttocks, with the tape parallel to the floor. Both measurements were taken while the subject was standing with feet closer together, arms at the side, body weight evenly distributed, and wearing little clothing. Also, the measurements were taken at the end of a normal expiration. Waist to Hip ratio (WHR) was calculated by taking the waist circumference (cm) and dividing by the hip circumference (cm).

3.2.4. Six Minute Walking Test

The ‘Six-Minute Walk’ Test (6MWT), a measure of the distance a person walks in 6 minutes, was used to assess physical performance of participants. The American Thoracic Society (ATS) indicated that 6MWT is the most frequently used, valid, inexpensive, popular,

easy to tolerate by patients easy to utilize, required minimal technological resources and representative to show daily activities comparing the other walking tests[69].

6 minute walking test was done in 30 meter, flat and hard corridor in the clinic according to ATS guidelines. We asked the patients can quickly walk for 6 minutes and the same researcher walked slightly behind the patient. The distance of the patient can walk was calculated. We explain the patients that they can stop or slow down if they feel dyspnea. The Borg Dyspnea Scale level, saturation, pulse and blood pressure were assessed at the beginning and the end of the test[70].

3.2.5. Dynamic Balance Assessment

Dynamic balance of the participants was assessed by Prokin PK 200(PK) dynamic balance instrument. PK is a circular mobile balance assessment. PK transmits data from platform to the computer with a wireless transmitter and it can detect each single angular movement with a chip inside the platform. Additionally PK has four different applicator (easy, medium, hard and rectangular) to place under the mobile platform [71].

We used the mobile platform with easy applicator and the patient stands on bipedally during .the 30 seconds. PK is connected to a computer by this way each single movement is recorded by computer in real time mode. There is a circle in the screen and and a coordinated system for the following changes. While the test was applying physiotherapist instructs participant to “Please keep indicator in the mid point of the circle as much as possible.” The results can be positive or negative.”

Figure 3.2. Prokin PK200 Instrument

Positive results in the AP measure means that patient mostly goes to anterior and positive results in the ML measure means that patient mostly lean on right foot. On the other hand, negative results in the AP measure shows that patient leans posteriorly, and the negative result in the ML measure shows that she leans on left foot.

3.2.6. Proprioception Assessment

The perception of the position and of the movement of various body parts in space can be defined as proprioception. Its main role is in sensory-motor control for balance, coordination movement acuity and joint stability, Its clinical evaluation is commonly based on the assessment of the joint position sense (JPS) [72].

JPS was assessed using the passive angle reproduction test. Through this, an assessor moved a participant's limb to a target position. This was returned to neutral, before finally moving the limb again, whilst requiring the participant to indicate when they thought the target angle was reached. The actual angular error (AAE) was calculated as the difference between the perceived angle and target angle. The target angle was determined 10^0 for dorsiflexion and 15^0 for plantar flexion [73].

Figure 3.3.Digital Goniometer

3.2.7. Superficial Sensory Evaluation

Two-point discrimination test evaluates the ability to perceive two points simultaneously applied to the skin. It is a measure of the smallest distance between two points of skin (applied simultaneously and with equal pressure). Aesthesiometer used to measure two point discrimination (Figure 3.4). Aesthesiometer consists of a small ruler with two moveable (sliding) tips covered with vinyl. The vinyl coverings help to diminish the impact of temperature on perception of contact. It is a hand-held instrument designed to measure the smallest distance that two points of contact on the skin can be distinguished [74]. Although 11 different sensory areas were defined on foot, we assessed two areas from these; one examination area was the midpoint of medial longitudinal arch and the other was the midpoint of lateral longitudinal arch [43].

Figure 3.4. Aesthesiometer

3.2.8. Vibration Perception Threshold Assessment

Biothesiometer was used to measure vibration perception threshold (VPT) (Figure 3.5). The biothesiometer probe vibrates at an amplitude proportional to the square of the applied voltage. The probe was applied perpendicular to the test site with a steady and firm pressure. Subjects were initially adapted to the sensation by holding the probe towards the distal palmar surface of hand. VPT was measured at the distal plantar surface of great toe of feet. If great toe suffered from ulcerations, VPT could be measured at the base of the first, third or fifth metatarsals. The voltage was slowly raised at the rate of 1 mV/sec. The value of VPT was defined as the voltage level when the subject pointed out that he or she first felt the vibration sense. If the averages of three record of VPT was $\geq$ 25mV, neuropathy was diagnosed [75]. Vibration threshold values were obtained from first, third and fifth metatarsal heads of feet in our study.

Figure 3.5.Biothesiometer

3.2.9. Assessment of Lower Extremity Muscles Strength

Quantitative myometry strength testing included quantitative myometry using a hand-held dynamometer (PowerTrack II commander, JTech Medical, Midvale, UT) to evaluate the maximum voluntary isometric force during muscle contraction of hip flexion/extension, hip abduction/adduction, knee flexion/extension, ankle plantar flexion and ankle dorsiflexion [76].

Figure 3.6. PowerTrack II Commander Myometry

3.3. Intervention

Exercise Education: Before the both exercise program, the patients were informed about the type 2 diabetes mellitus, symptoms and complications and also the evaluation methods, parameters and tests were explained. Patients also were informed about the importance and effects of exercise training, the exercise conditions to be considered and exercise precautions. Patients were warned not to make any changes to their drug doses during exercise training.

3.3.1. Aerobic Exercise Program

Both experimental and control groups participated in this program. The aerobic exercise program consists of 5 minutes warm up period and after that 30 minutes treadmill and finally 5 minutes cool down period.

Table 3.2. Aerobic Exercise Program

1.Week	5 minutes warm up period, stretching exercises (15seconds x 5 repetitions) 20 minutes walking on treadmill 5 minutes cool down period, stretching exercise (15seconds x 5 repetitions)
2.Week	5 minutes warm up period, stretching exercise (15seconds x 5 repetitions) 25 minutes walking on treadmill 5 minutes cool down period, stretching exercise (15seconds x 5 repetitions)
3.4.5.6.Weeks	5 minutes warm up period, stretching exercise (15seconds x 5 repetitions) 30 minutes walking on treadmill 5 minutes cool down period, stretching exercise (15seconds x 5 repetitions)

Warm-up period: 5 minutes warm up was performed with flexibility and stretching exercises such as hamstring, gastrosoleus, lumbar extensors and trunk lateral flexors stretching. Each exercises were done five repetitions and in 15 seconds (Figure 3.7)

Figure 3.7. Stretching Exercises

Aerobic Exercise: Treadmill walking was initiated with the 60% of maximal heart rate. When the patient walked for 20 minutes without difficulty, the speed was increased by 10% according to the tolerance of the patients. Subjects were continued walking at 3.5-6.5 km / h without any slope.

Cool-down period: The same flexibility and stretching exercises were repeated again for cool down period after the all exercise were completed.

Figure 3.8.Walking on Treadmill

3.3.2. Proprioceptive Training Program

Proprioceptive Exercise Group (PG) participated in proprioceptive training program combine with aerobic exercise program as described above. The proprioceptive training program was applied by physiotherapist under the supervision in the clinic twice a week respectively and all exercises except weight bearing on bosu were performed at home by the patient one day a week.

Table 3.3.Proprioceptive Exercise Program

		WEEK 1.2.3.	**WEEK 4.5.6**
1	Rolling the serrated sensory massage ball the soles of feet (bilaterally)	8 repetition x 3 sets	12 repetitions x 3 sets
2	Ankle pump exercises (bilaterally)		
3	Pulling and collection the one meter long sheet with toes (bilaterally)		
4	Sit to stand exercise		
5	Toe Rising		
6	Tandem walking on 5 meters long line		
7	Drawing"8"exercises with foot in standing position without visual information (bilaterally)		
8	Weight bearing on bosu trainer	Count steps up to 100	Count steps up to 200

Figure 3.9. Rolling The Serrated Sensory Massage Ball The Soles of Feet

Figure 3.10. Ankle Pump Exercise

Figure 3.11. Pulling and Collection the One Meter Long Sheet with Toes

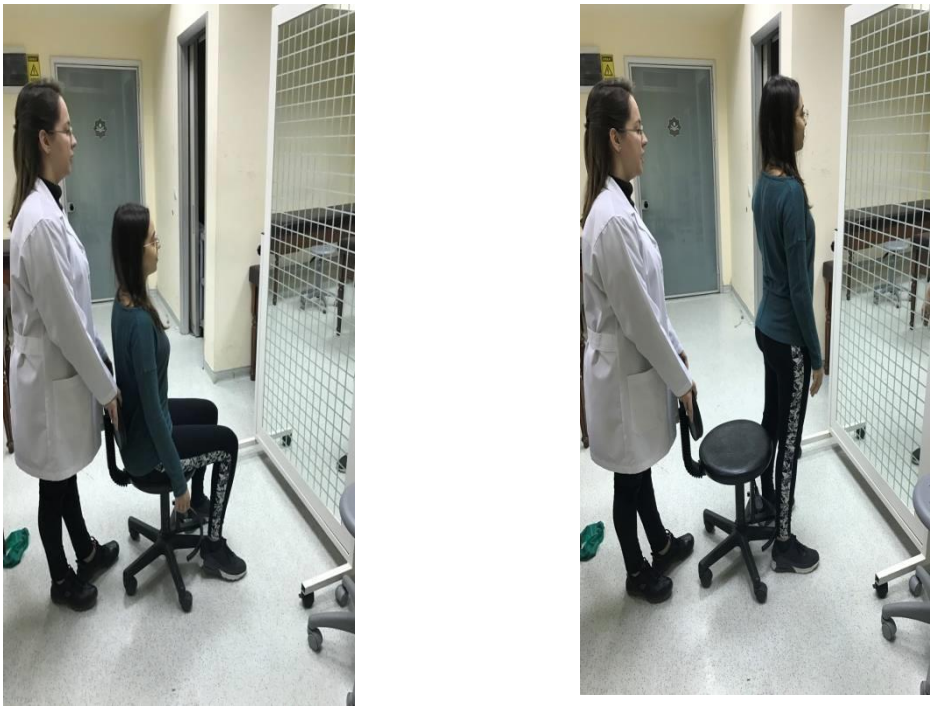


Figure 3.12. Sit to Stand Exercise

Figure 3.13. Toe Rising

Figure 3.14. Tandem Walking

Figure 3.15. Drawing"8" Exercises without Visual Feedback

Figure 3.16.Weight-bearing on Bosu Trainer

3.3.3. Resistive Exercise Training Program

The resistive exercise group (RG) participated in resistive training program combine with aerobic exercise program. All exercises was performed with 8 repetitions and three sets with green Thera-band initially. After 2 weeks, blue Thera-band was started to be used with the same repetitions instead of green one. Finally exercise was increased up 12 repetitions 3 sets with the blue Thera-band the last two weeks. These exercises were performed in clinic twice a week supervisely and also it was given home exercise program one day a week.

Table 3.4. Resistive Exercise Training Program

<table>
<tr><th colspan="2"></th><th>Week 1.2.</th><th>Week 3.4.</th><th>Week 5.6.</th></tr>
<tr><td rowspan="4">Ankle</td><td>Dorsiflexion</td><td rowspan="10">8 repetitions of each exercise for 3 sets with green Thera-band (8 rep x 3 sets)</td><td rowspan="10">8 repetitions of each exercise for 3 sets with blue Thera-band (8 rep x 3 sets)</td><td rowspan="10">12 repetitions of each exercise for 3 sets with blue Thera-band (12 rep x 3 sets)</td></tr>
<tr><td>Plantar Flexion</td></tr>
<tr><td>Inversion</td></tr>
<tr><td>Eversion</td></tr>
<tr><td rowspan="2">Knee</td><td>Flexion</td></tr>
<tr><td>Extension</td></tr>
<tr><td rowspan="4">Hip</td><td>Flexion</td></tr>
<tr><td>Extension</td></tr>
<tr><td>Abduction</td></tr>
<tr><td>Adduction</td></tr>
</table>

Figure 3.17. Resistive Ankle Exercises

Figure 3.18. Resistive Knee Exercises

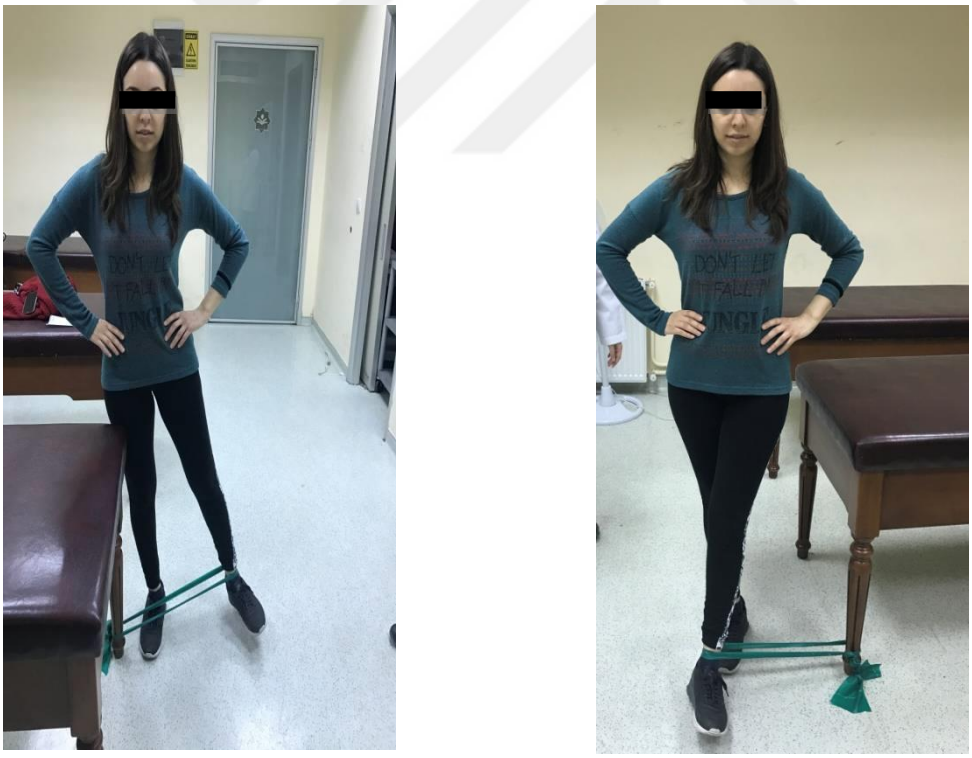


Figure 3.19. Resistive Hip Abduction-Adduction Exercises

Figure 3.20. Resistive Hip Flexion-Extension Exercises

After the 6 weeks exercise training program was completed, the brochure which included the general home exercise, exercise risks for diabetics was given all participants in order to be reminder and in order to provide continuity of exercise habits as a lifestyle modification (Appendix 4).

Data Analysis

Statistical Package Analyze for Social Sciences (SPSS) version 16.0 was used for data analyses. The Kolmogorov-Smirnov test was used to test the numerical variables for normality. The summary of numerical data was showed mean ± standard deviation and ratio was used for categorical data. Statistical analysis was performed before and after treatment for parametric and non-parametric data with respectively Paired Sample T-test and Wilcoxon test. The significance level was accepted 0.05.

4. RESULTS

The study included Type 2 diabetic patients (n=30, 24F/6M) who referred to Fitness Center in Pendik Arif Nihat Asya Kültür Merkezi, Istanbul, Turkey by a medical doctor between December 2016 and March 2017 and got diagnosed at least 6 months before.

The physical features (age, weight, height and body mass index (BMI)) of PG and RG are presented in Table 4.1. There were no statistically differences in age and height, weight and BMI in two groups.

Table 4.1. Physical Features of Participants

	PG mean±SD	**RG** mean±SD	**t**	**p value**
Age(year)	51.6±8.09	50.86±7.51	0.25	0.79
Weight (kg)	90.6±1.09	86.2±1.07	1.11	0.27
Height(m)	1.61±0.07	1.60±0.06	0.36	0.72
BMI(kg/m^2)	34.7±3.97	33.39±3.93	0.9	0.37

Data expressed as mean ± standard deviation. BMI: Body mass index. PG: Proprioceptive Exercise Group, RG: Resistive Exercise Group.

The gender, smoking habits, educational level, marital status and subdivision of BMI in the study groups were given in Table 4.2. There were no statistically significant differences according to gender, smoking habits, education level and marital status between two groups.

Subdivision of BMI is used to classify, according to World Health Organization classification, BMI values were not statistically differences. The data showed that 93.3 % of EG were found to be obese with BMI of 30.0 or above and 73.3% of RG were obese.

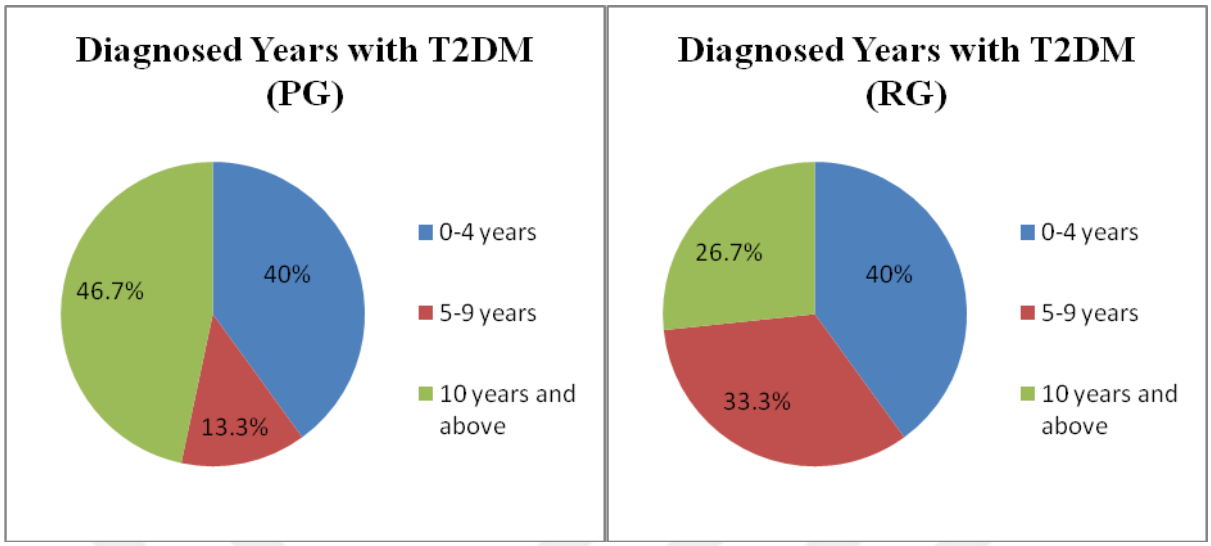
Table 4.2.Comparison of Sociodemographic Features, Smoking Habits and BMI categorization in PG and RG

		PG %(n)	RG %(n)	λ^2	p value
Gender	Female	80.0 (12)	80.0 (12)	0.00	1
	Male	20.0 (3)	20.0 (3)		
Smoking Habits	Yes	13.3 (2)	80.0 (2)	0.377	0.828
	Cessation	13.3 (2)	6.7(1)		
	No	73.3 (11)	13.3 (12)		
Marital Status	Single	86.7 (13)	93.3 (14)	1.03	0.5
	Married	13.3 (2)	6.7 (1)		
Education Level	Illiterate	0 (0)	6.7 (1)	2.69	0.44
	Primary School	93.3 (14)	73.3 (11)		
	High School	6.7(1)	13.3 (2)		
	University	0 (0)	6.7 (1)		
BMI (kg/m^2)	Overweight	6.7 (1)	26.7 (4)	3.58	0.31
	Obese	53.3 (8)	33.3 (5)		
	Severe obese	33.3(5)	40.0 (6)		
	Morbid obese	6.7 (1)	0 (0)		

Data expressed as % (n). BMI: Body mass index. PG: Proprioceptive Exercise Group, RG: Resistive Exercise Group.

The diagnosed years with T2DM were classified as in Graph 3.1. 40% of subjects have been diabetic patients for 0-4 years in both groups. Although 46.7% of subjects have been diabetic patients for 10 years and above in proprioceptive exercise group, 26.7% of subjects in resistive exercise group have been diabetic patients.(Graph 3.1.)

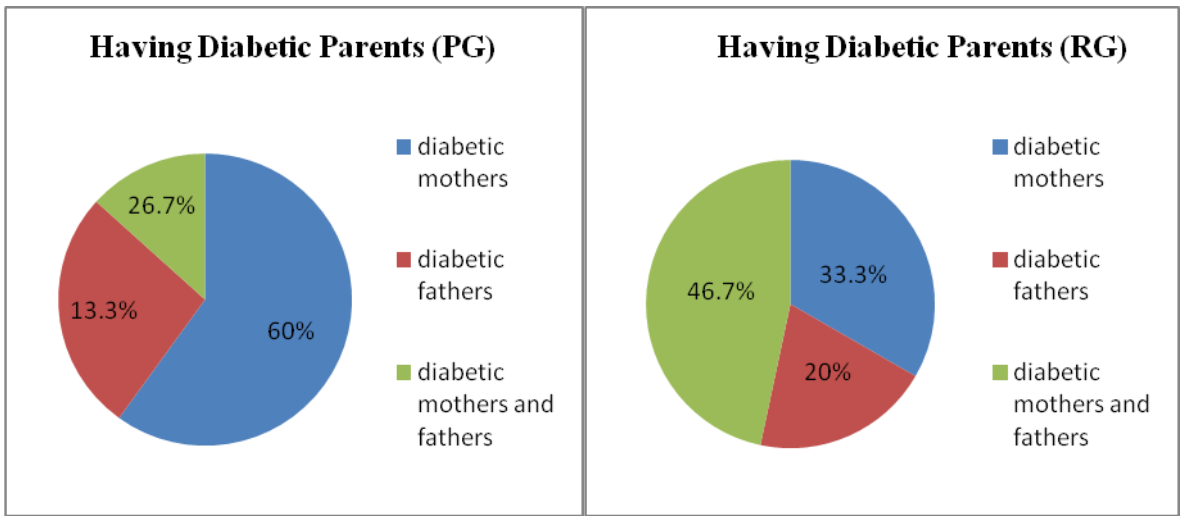
Graph 3.1. The Distribution of Diagnosed Years with T2DM



Data expressed as % .PG: Proprioceptive Exercise Group, RG: Resistive Exercise Group.

The subjects whether having diabetic parents or not were shown in Graph 3.1. Although 60% of subjects have diabetic mother in PG, 46.7% of RG have both diabetic mother and father. Only the 13.3% of subjects with PG have diabetic fathers while 20% of RG subjects have diabetic fathers (Graph 3.2.).

Graph 3.2. Distribution of Having Diabetic Parents



Data expressed as mean ± standard deviation. PG: Proprioceptive Exercise Group, RG: Resistive Exercise Group.

Apart from the T2DM having other chronic diseases such as hypertension, dyslipidemia and rheumatic disease were not found significant statistically differences in the study groups (Table 4.3). Hypertension was found 46.7% of PG and 66.7% of RG in diabetic patients

Table 4.3. Distribution of Systemic Diseases for PG and RG

			PG	**RG**	**λ^2 p value**
Systemic Disease	Hypertension	Yes	46.7(7)	66.7(10)	1.22 0.46
		No	53.3(8)	33.3(5)	
	Dyslipidemia	Yes	80(12)	53.3(8)	2.16 0.33
		No	20(3)	46.7 (7)	
	Rheumatic Disease	Yes	26.7(4)	6.7 (1)	2.4 0.24
		No	73.3(11)	93.3(14)	

Data expressed as % (n). BMI: Body mass index. PG: Proprioceptive Exercise Group, RG: Resistive Exercise Group.

An independent samples t-test was used to compare of variables between participants of PG and RG before interventions (Table 4.3). The data underlined that vibration perception thresholds (from first, third and fifth metatarsal heads of both feet) had statistically differences in both groups ($p<0.05$). The mean value of vibration was higher in PG compared with RG at all assessed points on feet. The mean value of first metatarsal head of right foot in PG was found higher in compared with RG (7.8±2.27 mV, 5.53±1.68 mV respectively, $p<0.05$)

Table 4.4. Comparison of Variables between PG and RG before interventions

			PG mean±SD	RG mean±SD	t	p value
Glycemic Control Variables	HbA1c		6.85±0.58	6.8±1.1	0.083	0.9
	Fasting Blood Glucose		153.27±38.9	142.4±59.9	0.58	0.56
Anthropometric Measurements	Waist circumference(cm)		104±7.75	101±6.85	1.14	0.26
	Hip circumference(cm)		119.93±12.91	115.86±6.10	1.15	0.25
	Waist Hip Ratio(cm)		0.87±0.06	0.87±0.06	-0.06	0.94
Functional Capacity	Six Minute Walking Test		410.27±67.9	433±78	-0.87	0.38
Dynamic Stability	Perimeter Length (m)		240.17±78.46	218.33±82.5	0.97	0.46
	Area Gap Percentage (%)		15.62±12.58	10.22±8.82	1.36	0.18
	Medium Speed (m/s)		8±2.61	7.27±2.75	0.74	0.46
	AP Equilibrium(cm)		2.31±1.39	1.55±1.1	1.65	0.10
	ML Equilibrium(cm)		0.5±0.39	0.87±0.53	**-2.11**	**0.04**
Proprioception Assessment *(Deviation from target angle)*	Right Dorsiflexion(10º)		2.32±1.06	2.58±1	-0.66	0.5
	Left Dorsiflexion(10º)		1.9±0.91	2.55±1.38	-1.52	0.13
	Right PlantarFlexion(15º)		2.45±1.02	2.2±1.08	0.65	0.51
	Left Plantar Flexion(15º)		2±1.06	2.17±1.1	-0.42	0.67
Vibration Perception Threshold	Right	1st metatarsal head (mV)	7.8±2.27	5.53±1.68	**3.10**	**0.004**
		3rd metatarsal head (mV)	7.9±2.43	5.26±1.33	**3.72**	**0.001**
		5th metatarsal head (mV)	8.06±2.52	5.66±1.95	**2.91**	**0.007**
	Left	1st metatarsal head (mV)	7.13±1.88	5.4±1.95	**2.47**	**0.02**
		3rd metatarsal head (mV)	7.2±2	5.46±2.35	**2.16**	**0.03**
		5th metatarsal head (mV)	8.2±2.95	5.33±2.02	**3.09**	**0.004**
Two Point Discrimination Sense Evaluation	Right	Medial Longitudinal Arch (cm)	1.6±0.39	1.58±0.41	0.9	0.92
		Lateral Longitudinal Arch (cm)	0.38±0.8	1.56±0.41	-1.09	0.28
	Left	Medial Longitudinal Arch (cm)	1.48±0.46	1.47±0.33	0.04	0.96
		Lateral Longitudinal Arch (cm)	1.42±0.29	1.5±0.45	-0.57	0.57

The lower extremity muscle strength test results were compared of variables between participants of PG and RG before interventions with independent sample t test. There was no any significant differences for muscle strength between two groups.

Table 4.5. Comparison of Lower Extremity Muscle Strength between PG and RG before interventions

	PG **Right** mean±SD	RG **Right** mean±SD	**Right** **p value** **t**	PG **Left** mean±SD	RG **Left** mean±SD	**Left** **p value** **t**
Ankle Dorsiflexion (lbs)	10.6±2.74	10.86±2.29	0.19 -1.3	10.33±2.55	11.46±1.8	0.36 -0.92
Ankle Plantar flexion (lbs)	11.06±2.28	11.66±1.98	0.44 -0.77	10.93±2.68	11.86±1.64	0.54 -0.6
Quadriceps (lbs)	12.06±1.90	12.2±2.33	0.86 -0.17	11.86±1.95	12.06±2.65	0.81 -0.23
Hamstring (lbs)	9.6±2.46	10.46±2.35	0.37 -0.9	9.73±2.49	10.53±2.47	0.38 -0.88
Hip Abductors (lbs)	13.46±2.77	14.1±1.95	0.45 -0.76	14±2.39	14.1±1.95	0.40 0.84
Hip Adductors (lbs)	11.66±1.79	11.53±1.55	0.83 0.21	11.26±2.6	11.66±2.52	0.67 -0.42
Hip flexors (lbs)	14.26±2.71	14.8±2.14	0.55 -0.59	14.46±2.53	15.53±2.58	0.24 -1.18
Hip extensors (lbs)	13.53±2.35	13.2±1.97	0.67 0.42	13±1.81	13.3±2.41	0.67 -0.42

Data expressed as mean ±standard deviation. Lbs: pound PG: Proprioceptive Exercise Group, RG: Resistive Exercise Group.

Comparing pre and post measurement findings of HbA1c and fasting blood glucose values were showed that both group had statistically significant differences in HbA1c and fasting blood glucose ($p<0.05$). It means that participants had improvement in results of HbA1c and fasting blood glucose during final measurements.

Table 4.6. Pre and Post Intervention Findings for Glycemic Control Variable

		PG mean±SD		**RG** mean±SD	
HbA1c	**Pre**	6.85±0.58	**p: 0.005** **t: 3.53**	6.82±1.10	**p:0.009** **t:3.01**
	Post	6.63±0.65		6.66±1.00	
Fasting Blood Glucose	**Pre**	153.27±38.9	**p:0.008** **t:3.08**	142.4±59.9	**p: 0.01** **t: 2.84**
	Post	135±20.00		127.13±41.63	

Data expressed as mean ± standard deviation. PG: Proprioceptive Exercise Group, RG :Resistive Exercise Group.

A paired t-test was used to examine for the differences in regard to pre and post test mean scores of anthropometric measurements. While resistive exercise group (RG) showed statistically significant difference in weight (kg) and body mass index (kg/m^2) ($p<0.05$), PG had vice versa. Waist circumference and hip circumference values were showed that both group had statistically significant decrease ($p<0.05$). It was witnessed that statistically significant decrease were observed in the mean of BMI and weight in RG ($p<0.05$) (Table 4.7).

Table 4.7. Intragroup Comparison of Pre and Post Intervention Findings for Anthropometric Measurements

		PG mean±SD		**RG** mean±SD	
Weight (kg)	**Pre**	90.6±1.09	p:0.07 t:1.94	86.2±1.07	**p:0.003 t:3.53**
	Post	90.06±11.04		84.93±9.99	
BMI (kg/m^2)	**Pre**	34.7±3.97	p:0.07 t:1.96	33.39±3.93	**p:0.003 t:3.57**
	Post	34.5±4.02		32.9±3.67	
Waist Circumference (cm)	**Pre**	104±7.75	**p:0.001 t:4.41**	101±6.85	**p:0.00 t:7.26**
	Post	100±8.16		97.2±6.5	
Hip Circumference (cm)	**Pre**	119.93±12.91	**p:0.00 t:5.52**	115.86±6.10	**p:0.00 t:7.76**
	Post	114.40±11.45		111.53±5.39	
Waist/Hip Ratio (cm)	**Pre**	0.87±0.06	p:0.08 t:-1.87	0.87±0.06	p:0.97 t:-0.03
	Post	0.88±0.06		0.87±0.06	

Data expressed as mean ±standard deviation. BMI: Body mass index. PG: Proprioceptive Exercise Group, RG: Resistive Exercise Group.

The differences of pre and post measurement in the aerobic capacity (6MWT) were found statistically significant in both groups. ($p<0.05$) (Tablo 4.8.)

Table 4.8. Comparison of Functional Capacity with 6 Minute Walking Test Results for Intragroup Value

			PG mean±SD	p value	RG mean±SD	p value
Functional Capacity	**6 MWT (m)**	**Pre**	410.27±67.9	**p:0.00 t: -6.41**	433±78	**p:0.004 t:-3.48**
		Post	485.67±67.6		497.13±35.71	

Data expressed as mean ±standard deviation. 6MWT: Six Minute Walking Test

When comparing of the participants for dynamic balance in two groups, there were statistically differences for all the sub parameters (perimeter length, area gap percentage, medium speed, and anteroposterior equilibrium) of dynamic stability in PG except mediolateral (ML) equilibrium value. Except the ML equilibrium all dynamic balance sub parameters were lower than the first values. However, statistically difference was not observed in RG (Table 4.7).

Table 4.9. Comparison of Dynamic Balance Measurements for Intragroup Variables

			PG mean±SD		RG mean±SD	
Dynamic Balance	**Perimeter Length (m)**	pre	240.17±78.46	**p:0.02 t:2.44**	218.33±82.5	p:0.70 t:0.38
		post	203.88±67.13		211.27±68.77	
	Area Gap Percentage (%)	pre	15.62±12.58	**p:0.01 t:2.65**	10.22±8.82	p:0.18 t:1.4
		post	6.57±4.08		7.61±8.06	
	Medium Speed (m/s)	pre	8±2.61	**p:0.02 t:2.44**	7.27±2.75	p:0.70 t:0.38
		post	6.79±2.23		7.04±2.29	
	AP Equilibrium (cm)	pre	2.31±1.39	**p:0.009 t:3.00**	1.55±1.1	p:0.08 t:1.85
		post	1.35±0.94		0.98±0.74	
	ML Equilibrium (cm)	pre	0.5±0.39	p:0.18 t:1.40	0.87±0.53	p:0.64 t:0.46
		post	0.29±0.34		0.71±0.94	

Data expressed as mean ±standard deviation. PG: Proprioceptive Exercise Group, RG: Resistive Exercise Group.

Table 4.10 showed that there were statistically differences between pre and post two point discrimination results among both group values except the midpoint of lateral longitudinal arch value in RG ($p<0.05$). Although there was no statistically difference between pre and post measurement findings of vibration values from left foot in RG, during the post measurement values of vibration from the left foot were significantly lower than during the post measurement findings in PG ($p<0.05$) (Table 4.10)

Table 4.10. Comparison of Foot Sensation Evaluation Results for Intragroup variables

				PG mean±SD	p value	RG mean±SD	p value
Vibration Perception Threshold	**Right**	1st metatarsal head (mV)	**Pre**	7.8±2.27	**p:0.008 t:3.11**	5.53±1.68	**p:0.003 t:3.56**
			Post	6.2±1.2		4.86±1.5	
		3rd metatarsal head (mV)	**Pre**	7.9±2.43	**p:0.01 t:2.95**	5.26±1.33	**p:0.05 t:2.08**
			Post	5.8±1.14		4.73±1.7	
		5th metatarsal head (mV)	**Pre**	8.06±2.52	**p:0.001 t:3.98**	5.66±1.95	p:0.06 t:1.97
			Post	5.46±1.3		5.2±2.21	
	Left	1st metatarsal head (mV)	**Pre**	7.13±1.88	**p:0.002 t:3.83**	5.4±1.95	p:0.08 t:1.85
			Post	5.8±1.47		4.66±1.39	
		3rd metatarsal head (mV)	**Pre**	7.2±2	**p:0.001 t:4.12**	5.46±2.35	p:0.12 t:1.62
			Post	5.6±1.91		4.53±1.59	
		5th metatarsal head (mV)	**Pre**	8.2±2.95	**p:0.00 t:4.88**	5.33±2.02	p:0.31 t:1.04
			Post	5.6±2.13		5±1.81	
Two Point Discrimination Sense Evaluation	**Right**	Midpoint of Medial Longitudinal Arch(cm)	**Pre**	1.6±0.39	**p:0.00 t:6.25**	1.58±0.41	**p:0.00 t:5.26**
			Post	1.14±0.35		1.07±0.35	
		Midpoint of Lateral Longitudinal Arch(cm)	**Pre**	1.16±0.17	**p:0.02 t:2.53**	1.56±0.41	**p:0.00 t:4.65**
			Post	0.38±0.8		1.08±0.2	
	Left	Midpoint of Medial Longitudinal Arch (cm)	**Pre**	1.48±0.46	**p:0.002 t:3.83**	1.47±0.33	**p:0.002 t:3.76**
			Post	1.08±0.24		1.08±0.28	
		Midpoint of Lateral Longitudinal Arch (cm)	**Pre**	1.42±0.29	**p:0.00 t:5.29**	1.5±0.45	p:0.08 t:1.88
			Post	1.09±0.24		1.20±0.31	

Data expressed as mean ± standard deviation. mV: milivolt, cm:centimeter PG:Proprioceptive Exercise Group, RG:Resistive Exercise Group.

According to paired sample t-test results, there were significant differences for intragroup variables between study groups for proprioceptive deviation from target angle ($p<0.05$). The results showed that the mean of proprioceptive deviations were decreased in both groups ($p<0.05$) (Table 4.11).

Table 4.11. Intragroup Comparisons of Pre and Post Intervention Findings for Proprioceptive Assessment

			PG mean±SD		**RG** mean±SD	
Proprioception Assessment *(Deviation from target angle)*	Right Dorsiflexion(10^o)	pre	2.32±1.06	**p:0.00**	2.58±1	**p:0.00**
		post	0.94±0.72	**t:6.29**	0.94±0.87	**t:10.11**
	Left Dorsiflexion(10^o)	pre	1.9±0.91	**p:0.00**	2.55±1.38	**p:0.00**
		post	0.88±0.67	**t:4.79**	1.11±0.96	**t:4.93**
	Right Plantar Flexion(15^o)	pre	2.45±1.02	**p:0.00**	2.2±1.08	**p:0.00**
		post	1.25±0.75	**t:5.53**	0.96±0.7	**t:5.13**
	Left Plantar Flexion(15^o)	pre	2±1.06	**p:0.002**	2.17±1.1	**p:0.00**
		post	1.02±1.04	**t:3.71**	0.82±0.8	**t:5.98**

Data expressed as mean ± standard deviation. PG: Proprioceptive Exercise Group, RG: Resistive Exercise Group.

A paired sample t-test was executed to examine changes of each group across the pre and post intervention measurements on lower extremity muscle strength test. The results showed that there were a statistically significant improvements for lower extremity muscle strength means of volunteers during pre and post measurements in each group ($p<0.05$). A statistically significant improvement was observed in both groups during post measurement ($p<0.05$) (Table 4.12).

Table 4.12. Comparison of Lower Extremity Muscle Strength Test Results for Intragroup variables

			PG mean±SD	p value	RG mean±SD	p value
Right (lbs)	**Ankle Dorsiflexion**	**Pre**	7.66±2.22	**p:0.00 t:-5.27**	8.8±2.45	**p:0.002 t:-3.9**
		Post	10.6±2.74		10.86±2.29	
	Ankle Plantar flexion	**Pre**	8.93±2.65	**p:0.00 t:-5.03**	9.73±2.96	**p:0.003 t:-3.65**
		Post	11.06±2.28		11.66±1.98	
	Quadriceps	**Pre**	12.06±1.90	**p:0.003 t:-3.58**	12.2±2.33	**p:0.001 t:-4.38**
		Post	14±3		13.73±2.37	
	Hamstring	**Pre**	9.6±2.46	**p:0.00 t:-4.88**	10.46±2.35	**p:0.008 t:-3.08**
		Post	11.6±1.88		12.13±2.44	
	Hip Abductors	**Pre**	13.46±2.77	**p:0.005 t:-3.29**	14.1±1.95	**p:0.002 t:-3.83**
		Post	15.2±1.97		16±1.92	
	Hip Adductors	**Pre**	11.66±1.79	**p:0.01 t:-2.69**	11.53±1.55	**p:0.001 t:-4.12**
		Post	12.53±1.59		13.13±1.24	
	Hip flexors	**Pre**	14.26±2.71	**p:0.007 t:-3.15**	14.8±2.14	**p:0.005 t:-3.28**
		Post	16.06±1.53		16.8±1.42	
	Hip extensors	**Pre**	13.53±2.35	**p:0.04 t:-2.23**	13.2±1.97	**p:0.004 t:-3.45**
		Post	14.73±2.43		14.53±1.8	
Left (lbs)	**Ankle Dorsiflexion**	**Pre**	7.6±2.5	**p:0.00 t:-4.77**	8.46±2.64	**p:0.00 t:-5.52**
		Post	10.33±2.55		11.46±1.8	
	Ankle Plantar flexion	**Pre**	8.86±3.02	**p:0.00 t:-5.99**	9.53±2.99	**p:0.00 t:-4.54**
		Post	10.93±2.68		11.86±1.64	
	Quadriceps	**Pre**	11.86±1.95	**p:0.006 t:-3.27**	12.06±2.65	**p:0.001 t:-4.17**
		Post	13.6±3.2		14.26±2.18	
	Hamstring	**Pre**	9.73±2.49	**p:0.00 t:-4.8**	10.53±2.47	**p:0.01 t:-2.67**
		Post	11.6±1.88		12.2±2.36	
	Hip Abductors	**Pre**	14±2.39	**p:0.01 t:-2.98**	14.1±1.95	**p:0.00 t:-5.01**
		Post	14.86±1.92		16±1.73	
	Hip Adductors	**Pre**	11.26±2.6	**p:0.04 t:-2.24**	11.66±2.52	**p:0.02 t:-2.44**
		Post	12.73±1.53		13.13±2.03	
	Hip flexors	**Pre**	14.46±2.53	**p:0.01 t:-2.98**	15.53±2.58	**p:0.04 t:-2.21**
		Post	16.2±2		17.13±1.5	
	Hip extensors	**Pre**	13±1.81	**p:0.009 t:-3.02**	13.3±2.41	**p:0.02 t:-2.44**
		Post	14.26±1.83		15±2.03	

Data expressed as mean ± standard deviation. Lbs: pounds PG: Proprioceptive Exercise Group, RG: Resistive Exercise Group.

Independent samples t-test were done to investigate the differences of glycemic control variables, anthropometric measurements and functional capacity between pre and post measurements to calculate intergroup differences (Table 4.13). There was no statistically significant difference of mean weight in the participants between the two groups, although there was a greater weight reduction in RG than the other.

Table 4.13. Comparison of difference between Pre and Post Findings of Glycemic Control Variables, Anthropometric Measurements and Functional Capacity in Intergroup Variables

		PG mean±SD	RG mean±SD	t	p value
Glycemic Control Variables	Δ HbA1c (%)	-0.22±0.25	-0.16±0.2	0.62	0.53
	Δ Fasting Blood Glucose	-18.06±23.1	-15.26±20.08	0.73	0.73
Anthropometric Measurements	ΔWeight (kg)	-0.53±1.06	-1.26±1.38	1.62	0.11
	ΔBMI (kg/m^2)	-0.2±0.4	-0.48±0.52	1.66	0.1
	Δ Waist circumference(cm)	-3.26±2.86	-3.73±1.98	-0.51	0.6
	Δ Hip circumference(cm)	-5.53±4.10	-4.33±2.16	1.00	0.32
	Δ Waist Hip Ratio(cm)	0.01±0.02	0.00±0.01	-1.46	0.15
Functional Capacity	Δ 6MWT	75.4±45.49	63.4±70.47	0.55	0.58

Data expressed as mean ±standard deviation. BMI: Body mass index. 6MWT: 6 Minute Walking Test PG: Proprioceptive Exercise Group, RG: Resistive Exercise Group. Δ: Post values minus pre values.

Table 4.14 was shown the differences of dynamic stability, proprioception assessments and superficial sense evaluations and vibration perception threshold values between pre and post measurements to calculate intergroup differences. The mean of proprioceptive deviations were decreased in both groups, so there was no statistically difference between two groups. Although there were significant improvements in dynamic stability sub parameters of PG, there was no statistically significant difference between the two groups.

There were statistically deviations on the vibration values of 3rd metatarsal head (mV) and 5th metatarsal head (mV) of right foot and 5th metatarsal head (mV) of left foot. ($p<0.05$). The data highlighted that PG enhanced these parameters differentiate to RG (Table 4.14).

Table 4.14. Comparison of Difference between Pre and Post Measurements of Dynamic Stability, Proprioception Assessment and Foot Sensation Evaluation

			PG mean±SD	**RG** mean±SD	**t**	**p value**
Dynamic Stability	Δ Perimeter Length (m)		-36.28±57.57	-7.06±70.96	-1.23	0.22
	Δ Area Gap Percentage (%)		-9.04±13.1	-2.6±7.19	-1.66	0.10
	Δ Medium Speed (m/s)		-1.21±1.91	-0.23±2.36	-1.24	0.22
	Δ AP Equilibrium(cm)		-0.95±1.23	-0.56±1.18	-0.87	0.38
	Δ ML Equilibrium(cm)		-0.21±0.59	-0.15±1.29	0.55	0.58
Proprioception Assessment *(Deviation from target angle)*	Δ Right Dorsiflexion(10^o)		-1.38±0.84	-1.64±0.62	0.95	0.34
	Δ Left Dorsiflexion(10^o)		-1.01±0.81	-1.44±1.12	1.18	0.24
	Δ Right Plantar Flexion(15^o)		-1.20±0.83	-1.23±0.93	0.10	0.91
	Δ Left Plantar Flexion(15^o)		-0.98±-1.34	1.02±0.87	1.03	0.31
Vibration Perception Threshold	Right	Δ 1^{st} metatarsal head (mV)	-1.6±1.99	-0.66±0.72	-1.70	0.09
		Δ 3^{rd} metatarsal head (mV)	**-2.13± 2.79**	**-0.53 0.99**	**-2.08**	**0.04**
		Δ 5^{th} metatarsal head (mV)	**-2.60± 2.52**	**-0.46± 0.91**	**-3.07**	**0.005**
	Left	Δ 1^{st} metatarsal head (mV)	-1.33± 1.34	-0.73± 1.53	-1.13	0.26
		Δ 3^{rd} metatarsal head (mV)	-1.60± -0.93	-0.93 ±2.21	-0.96	0.34
		Δ 5^{th} metatarsal head (mV)	**-2.60± -0.33**	**-0.33± 1.23**	**-3.65**	**0.001**
Two Point Discrimination Sense Evaluation	Right	Δ Medial Longitudinal Arch (cm)	-0.46± 0.28	-0.51± 0.37	0.43	0.66
		Δ Lateral Longitudinal Arch (cm)	-0.23 ± 0.35	-0.47± 0.39	1.75	0.09
	Left	Δ Medial Longitudinal Arch (cm)	-0.39± 0.39	-0.38± 0.39	-0.04	0.96
		Δ Lateral Longitudinal Arch (cm)	-0.33± 0.24	-0.3± 0.61	-0.19	0.84

Data expressed as mean ± standard deviation. PG: Proprioceptive Exercise Group, RG:Resistive Exercise Group. Δ: Post values minus pre values.

According to independent samples t-test results, there was a significant difference for intergroup variables between participants involved in PG and RG for hip abductor muscle strength (Table 4.15.). The difference in the hip abductor muscle strength of the RG is more than PG and statistically significant.($p<0.05$)

Table 4.15. Comparison of Difference between Pre and Post Muscle Strength Measurements of Intergroup Variables

		PG Right mean±SD	**RG** Right mean±SD	**p value**	**PG** Left mean±SD	**RG** Left mean±SD	**p value**
Lower Extremity Muscle Strength (lbs)	Δ Ankle Dorsi flexors	2.93±2.15	2.06±2.05	p:0.26 t:1.12	2.73±2.21	3.00±2.10	p:0.73 t:-0.33
	Δ Ankle Plantar flexors	2.13±1.64	1.93±2.05	p:0.77 t:0.29	2.06±1.33	2.33±1.98	p:0.67 t:-0.43
	Δ Quadriceps	1.93±2.08	1.53±1.35	p:0.53 t:0.62	1.73±2.05	2.20±2.04	p:0.53 t:-0.62
	Δ Hamstring	1.93±1.53	1.66±2.09	p:0.69 t:0.39	1.86±1.50	1.66±2.41	p:0.78 t:0.27
	Δ Hip Abductors	1.73±2.01	1.86±1.88	p:0.85 t:-0.18	0.86±1.12	2.66±2.05	**p:0.006* t:-2.97**
	Δ Hip Adductors	0.86±1.24	1.60±1.50	p:0.15 t:-1.45	1.46±2.53	1.46±2.32	p:1 t:0
	Δ Hip flexors	1.80±2.21	2±2.36	p:0.81 t:-0.24	1.73±2.25	1.60±2.79	p:0.88 t:0.14
	Δ Hip extensors	1.2±2.07	1.33±1.49	p:0.84 t:-0.20	1.26±1.62	1.66±2.33	p:0.62 t:-0.5

Data expressed as mean ± standard deviation. lbs: pounds PG: Proprioceptive Exercise Group, RG:Resistive Exercise Group. Δ: Post values minus pre values.

5. DISCUSSION

The main outcome of this study is that, compared with resistive exercise training (RG) and proprioceptive exercise training, a program including aerobic exercises with proprioceptive exercise training can lead to greater improvement in vibration perception threshold which was obtained from third and fifth metatarsals head of right foot and from fifth metatarsal head of left foot) according to statistical analysis (Table 4.14), ($p<0.05$). Consistent with hypothesis we found that proprioceptive exercises combined with aerobic exercise program was more effective to improve vibration sense and dynamic balance findings of people with T2DM compared to combination of resistive exercise and aerobic exercise program. However, we may imply that combination of resistive exercise with aerobic exercise program was more effective on weight loss of individuals than proprioceptive exercises combined with aerobic exercise program.

The beneficial effects of exercise are well recognized in glucose control of Type 2 diabetics. Exercise training was considered to control glycemic control by controlling HbA1c and fasting and postprandial blood glucose levels, regulating the lipid profile and reducing cardiovascular disease risk factors[77]. In the metaanalyses it has been shown that the structured programs including aerobic and resistive exercises can reduce the HbA1c level by 0.6 [78]. Another study reported that HbA1c improved by 0.38-0.97% with combined training for 130-270 min per week for 6 months[79]. In our study, the proprioceptive exercise group (PG) and the resistive exercise group (RG) combined with aerobic exercise have decrease in HbA1c level 0.2%. HbA1c and fasting blood glucose level outcomes showed statistically significant improvements in both combined training groups ($p<0.05$). Even those small change in values below the minimal clinical change (1%) in HbA1c are similar to those obtained with pharmacological interventions, have positive effect and clinically significant in the absence of microvascular macrovascular conditions[80]. There was no superiority in HbA1c changes of two combined exercise groups in 6 weeks exercise period, so it can be concluded that the combination of proprioceptive exercise with aerobic exercise could be provided as an alternative to resistive exercises combined with the aerobics recommended in the literature.

There was no statistically significant differences in body weight, height, body mass index, waist and hip circumferences, waist/hip ratio between the two exercise groups during pre intervention. According to our records we found that all the subjects (n=30) were obese with body mass index of over 30 kg/m^2. It was described that although body mass index

(kg/m^2) has been used as a measure of general obesity, waist circumference and waist/hip ratio have been attributed as measures for central obesity [81]. In the literature, increased visceral adipose tissue leads to high waist circumference (WC), and WC is valuable data, recommended for anthropometric measure of pathogenic adipose tissue distribution. It was explained that T2DM is directly relationship with increasing of abdominal adipose tissue so it was reported that reflecting an important risk factor of T2DM person having increased waist hip circumference ratio had increasing risk for diagnosed T2DM [68]. With the prospective studies the waist–hip ratio were also explained a risk of myocardial infarction. It was suggested cut off points for a waist circumference of 85 cm in women and 90 cm in men, and for a waist–hip ratio 0.84–0.86 in women, 0.90–0.91 in men in the literature [82]. In our study, mean of waist circumference among women was 103.5 cm in PG during pre intervention, the value was decreased to 100 cm after 6 weeks exercise training. The mean value of waist circumference was 99.5 cm in RG among women during pre intervention, the value was decreased to 95.4 after the exercise program was completed so the waist circumference were statistically significant reduction in both exercise groups ($p<0.05$). These improvements were not seen in the waist / hip ratio value, there were similar reductions in hip circumference measurements of both groups it remained constantly at the value of 0.83 cm among women. Although it was succeed changing in waist circumference values, the measurements have not been reached within the suggested cut off point yet. Therefore, our exercise program may be prescribed for longer periods, it leads to more beneficial effects on waist circumference. Sigal et al. [79] reported that while the body weight and body mass index measurements were decreased in the aerobic training group, waist circumference value was decreased in aerobic and resistance training group compared to sedentary group. Intergroup differences were not statistically significant in his study like ours [79]. However resistive exercise group (RG) showed statistically significant reduction in weight (kg) and body mass index (kg/m^2), PG had vice versa in our study. Snowling et al noted that exercise training could reduce body weight by an average of 5.1% and body fat by 15% in T2DM in meta analyses [10].They also indicated that when the aerobic exercise training provides the reduction in body weight, it was demonstrated that the resistive exercise training combined with aerobic exercises led to decrease body fat [83]. We may believe that resistive exercises or proprioceptive exercises combined with aerobic exercises can be suggested to reach cut off points of anthropometric measurements.

According to current guidelines of ADA and ACSM, it is recommended to use cardiopulmonary exercise test (CPET) in order to able to detect CVD risks and create an

appropriate exercise program[8]. CPET is not common for T2DM due to the financial disadvantages and trained personal requirement. Instead of CPET, 6 MWT is preferred especially to determine aerobic capacity in clinical circumstances [69]. Stewart et al. [84] stated that 469 m distance was recorded in healthy subjects while the 394 m distance was obtained in uncomplicated T2DM patients. In our study, the improvement of distance obtained from 6MWT recovery was achieved for both groups at the end of treatment. The groups have no superiority to each other and we think that the functional capacity increased similarly due to participated aerobic exercises combined with special exercises training in both groups.

According to present study, only the subjects of PG showed reduction in mean values of dynamic balance for sub parameters of Perimeter Length, Area Gap Percentage, AP equilibrium and Medium Speed during post intervention measurements (Table 4.7), ($p<0.05$). Although the intergroup variables were not seen statistically differences, improvements in mean value of the changes between pre and post measurements for dynamic balance parameters were found statistically significant in subjects of PG compared to RG. Morrison et al. [85] demonstrated that a 6 weeks program of three times in a week, supervised balance and resistance training had positive effects on balance, proprioception, lower-limb strength and reaction time in patients with T2DM regardless of whether they had neuropathy. A randomized controlled trial study showed that 12 weeks of twice weekly, gait and balance exercises (heel/toes standing, tandem walking, sit to stand exercises etc.) combined with function-orientated strengthening could improve balance and gait speed of diabetics when compared to the control group that received no treatment [86]. Although we did not have a control group in our study, we observed that balance sub parameters were improved in the PG than the RG. We think that the reason why the PG participated our training program as suggested in the study of Allet et al.[86] performing proprioceptive and balance exercises combined with aerobic exercise it may have more positive effects on balance parameters.

Superficial sense of feet was evaluated by an aesthesiometer and two point discrimination test was used from the midpoint of medial and lateral longitudinal arch of feet plantar surface in this study. In the literature, it was reported that the direct measure of sensory loss for diabetic subjects on foot and it was found the relationship between the two point discrimination test results and mechanoreceptor density [87]. In addition, plantar surface area was showed the essential source collecting senses for static and dynamic balance of body[88]. Although there were few studies using two point discrimination test in patients with diabetes, one of the study found that there was no difference in the healthy control group and

diabetic patients without neuropathy in the literature [87]. In our study, there was statistically difference between pre and post two point discrimination test results among both group values except the midpoint of lateral longitudinal arch value in RG ($p<0.05$). Therefore, resistive exercise or proprioceptive exercise can be used to improve touch discrimination sense of feet for diabetics.

Vibration perception threshold was measured by a biothesiometer from first, third and fifth metatarsal head of both feet. Although there was no statistically difference between pre and post measurement findings of vibration values from left foot in RG, the left foot of post measurement vibration values were significantly lower than pre measurement findings in PG ($p<0.05$). Balducci et al. [41] found that exercise group which was performed 4 hours a week brisk walking on treadmill with the intensity of 50% to 85% of the heart rate had lower level of vibration perception threshold from hallux when compared to the sedentary control group and it was found statistically significant. Even though the vibration threshold values of PG were higher than RG before interventions, PG had more improvements according to intergroup variable differences at the end of the 6 week exercise program in our study. Proprioceptive exercises may be used to decrease vibration threshold and for improvement of deep sense and they may also be preferred instead of resistive exercises for elderly diabetic patients at risk of complication.

In this study, ankle joint proprioception sense was evaluated by angle reproduction test in direction of dorsiflexion and plantar flexion. According to results, there were significant differences for intragroup variables between participants involved in RG and PG during post measurements. We observed that the mean of proprioceptive deviations from target angle were decreased in both groups (Table 4.11). Guney et al. [73] found that diabetic patients had higher deficits for ankle proprioception sense especially in direction of plantar flexion compared to healthy subjects. They also indicated that proprioceptive deficits caused insufficient muscle strength so the proprioceptive exercise and muscle strengthening exercise training should be initiated even if diabetic patients did not have neuropathy due to prevention the early prevention of complications. In another study was done with elderly individuals, both the diabetic group and healthy subjects group had improvements in proprioception after the supervised balance and resistance training exercise [85]. We concluded that resistive ankle exercises or proprioceptive exercises for ankle can be preferred to improve proprioception sense.

It was mentioned that muscle strength loss was present in patients with T2DM. Impairment of sensorimotor function and decrease in proprioceptive feedback led to poor

muscle strength and poor postural control[67]. Park et al. [40] found that muscle quality decreased in older adults with diabetes and that prevents physical activity. However, they pointed out that increasing the muscle mass and muscle strength of patients could also affect the functional capacity positively. According to our muscle strength test results, there was a significant difference for intergroup variables between participants involved in PG and RG in hip abductor muscle strength test ($p<0.05$) (Table 4.15). The difference in the hip abductor muscle strength of the RG which performed resistive exercises training group is more than PG and statistically significant. However, the lower extremity muscle strength means of participants showed that statistically significant improvements for during pre and post measurements in both groups. Dunstan et al. [89] compared with the upper and lower body muscle strength between the resistive exercise plus weight loss exercise program and gymnasium-based weight loss exercise program. They found that more improvements of muscle strength in resistive exercise plus weight loss exercise program. The intergroup differences were maintained with home based exercise program at 9 and 12 months in their study. Thus, we considered that muscle strength may be improved with the proprioceptive or resistive exercise program and may have beneficial effects for good glycemic control.

As far as we know, no studies published to investigate the influence on proprioceptive exercises or resistive exercises on dynamic balance or superficial sense for people with T2DM

Much of the literature suggested to maintain glycemic control and functional capacity of diabetic patients that the aerobic exercise programs can be combined with the resistive exercise. In addition to that researches showed that balance training can enhance with resistive or strength training to improve dynamic balance, proprioception and superficial sense. However, there is a gap in the literature which exercise protocol is more effective and how to optimize adequate exercise type and intensity for improvement of balance and glycemic control. In the light of our results, we would like to point to glycemic control can be positively influenced from the combination of aerobic exercise training and proprioceptive exercises that can improve balance and superficial sense.

The limitations of our study;

-We did not have a control group to compare exercise training groups.

-We included a small size of study (n=30), it was inadequate for generalizing the results.

-The long follow-up results were needed to evaluate the long term effects of two combined exercise programs on dynamic balance, superficial sense and glycemic control.

CONCLUSION AND SUGGESTIONS

- Glycemic control, physical parameters, functional capacity, lower extremity muscle strength, balance and superficial sensation can be improved with proprioceptive exercise training combined with aerobic exercise in type 2 diabetic patients.
- Aerobic exercise and proprioceptive exercise training may also improve glycemic control as an alternative to the combined aerobic exercise and resistive exercise training described in the literature for type 2 diabetic patients.
- At the end of treatment, the improvements obtained with both combined exercise training were similar except for the vibration threshold value and dynamic balance parameters.
- There were positive changes for dynamic balance parameters and vibration perception threshold values of proprioceptive exercise group participants compared to the other group.
- Although the difference in glycemic control variables such as fasting blood glucose level and HbA1c level were similar in both groups, weight loss was higher in the resistive exercise group than proprioceptive exercise group.
- The combination of proprioceptive exercise training and aerobic exercises may be preferred for exercise program of diabetics because of the similarity of glycemic effects with the combination of aerobic exercises and resistive exercises and it also provides the improvement balance and superficial sensation to protect complications of diabetes.
- Proprioceptive exercises may also be preferred instead of resistive exercises for elderly diabetic patients at risk of complication.

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APPENDIX 1: INFORMED WRITTEN CONSENT

Grup 1(Deney Grubu) Katılımcı Onam Formu

Bu anket, Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon Anabilim Dalı, Yüksek Lisans Tezi için hazırlanan **"Tip 2 Diyabetli Hastalarda Resistif Egzersiz ya da Propriyoseptif Egzersiz Eğitiminin Denge ve Yüzeysel Duyu Üzerine Etkileri"** adlı araştırma kapsamında yapılmaktadır. Araştırma kapsamında çalışmaya katılmayı kabul eden gönüllü bireylere yaklaşık 35 sorudan oluşan 20 dakika sürecek olan demografik özellikleri sorgulayan bir anket ile genel sağlık durumu değerlendirme anketi (SF-12) sözlü yanıt alınarak yüz yüze uygulanacaktır. Sonra uygulamalı değerlendirme testlerine geçilecektir. Dinamik denge değerlendirmesi Prokin PK 200 hareketli platforma sahip bir cihazla, ayak bileği propriosepsiyon değerlendirmesi elektronik bir gonyometre(açı-ölçer) ile değerlendirilecektir. Semmes-weisten monofilament testi için 5.07/10 g kalınlığına sahip bir kıl ayak tabanınıza dokundurularak hissedip hissetmediğinize bakılacaktır. İki nokta diskriminasyonu için aralığı gittikçe daralabilen (estezyometre) bir araç ayak tabanınıza dokundurulacak ve ayak tabanında iki nokta veya tek nokta hissettiğiniz aralıklar değerlendirilecektir. Vibrasyon ile duyu değerlendirmesi testi biyotezyometre adı verilen cihaz ile değerlendirilecek olup hafif bir titreşim ayak tabanınıza verilerek hissettiğiniz eşik değer kaydedilecektir.Son olarak aerobik kapasiteyi değerlendirmek için 6 dakika yürüme testi (6 MWT) uygulanacaktır; 6 dakika belirlenen 30 metre uzunluğundaki alanda yürüyerek, dakikadaki kalp hızı ve yürüme mesafeniz kaydedilecektir. Çalışmamızda olgular randomize (rastgele) olarak iki gruba ayrılacaktır. Bu grubuna (Grup 1) aerobik egzersiz programı ile birlikte propriyoseptif egzersiz eğitimi yapılacaktır. Bu eğitim kapsamında öncelikle koşu bandında 5 er dakika ısınma ve soğuma periyodu ile birlikte 30 dk normal kalp hızında yürüme, ayak tabanına duyu masaj topu ve duyu fırçası ile uygulama, ayak bileği pompa egzersizleri, parmak ucuna yükselme egzersizleri de dahil edilecektir. Haftada 1 gün bu uygulama ev egzersiz programı olarak verilecektir. 6 haftanın sonunda ön testler tekrarlanarak, ölçümler kayıt edilecektir.

Araştırmada yapılan değerlendirmelerin sonuçları yalnızca araştırma kapsamındaki çalışmalarda kullanılacaktır. Kişisel bilgileriniz herhangi bir amaçla, kurum yöneticileri veya üçüncü kişilerle paylaşılmayacaktır. Katılımınız için teşekkür ederiz.

Sorumlu Araştırmacı: Fzt. Güzin Kaya Aytutuldu - 05366265884

""**Tip 2 Diyabetli Hastalarda Resistif Egzersiz ya da Propriyoseptif Egzersiz Eğitiminin Denge ve Yüzeysel Duyu Üzerine Etkileri"ni** incelemek amacıyla yapılan bu çalışmaya hiçbir baskı ve zorlama olmaksızın kendi rızamla katılmayı kabul ediyorum.

Gönüllünün Adı / Soyadı / İmzası / Tarih

Açıklamaları Yapan Kişinin Adı / Soyadı / İmzası / Tarih

Grup 2 (Kontrol Grubu) Katılımcı Onam Formu

Bu anket, Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon Anabilim Dalı, Yüksek Lisans Tezi için hazırlanan"**Tip 2 Diyabetli Hastalarda Resistif Egzersiz ya da Propriyoseptif Egzersiz Eğitiminin Denge ve Yüzeysel Duyu Üzerine Etkileri"**adlı araştırma kapsamında yapılmaktadır. Araştırma kapsamında çalışmaya katılmayı kabul eden gönüllü bireylere yaklaşık 35 sorudan oluşan 20 dakika sürecek olan demografik özellikleri sorgulayan bir anket ile genel sağlık durumu değerlendirme anketi (SF-12) sözlü yanıt alınarak yüz yüze uygulanacaktır. Sonra uygulamalı değerlendirme testlerine geçilecektir. Dinamik denge değerlendirmesi Prokin PK 200 hareketli platforma sahip bir cihazla, ayak bileği propriosepsiyon değerlendirmesi elektronik bir gonyometre(açı-ölçer) ile değerlendirilecektir. Semmes-weisten monofilament testi için 5.07/10 g kalınlığına sahip bir kıl ayak tabanınıza dokundurularak hissedip hissetmediğinize bakılacaktır. İki nokta diskriminasyonu için aralığı gittikçe daralabilen (estezyometre) bir araç ayak tabanınıza dokundurulacak ve ayak tabanında iki nokta veya tek nokta hissettiğiniz aralıklar değerlendirilecektir. Vibrasyon ile duyu değerlendirmesi testi biyotezyometre adı verilen cihaz ile değerlendirilecek olup hafif bir titreşim ayak tabanınıza verilerek hissettiğiniz eşik değer kaydedilecektir.Son olarak aerobik kapasiteyi değerlendirmek için 6 dakika yürüme testi (6 MWT) uygulanacaktır; 6 dakika belirlenen 30 metre uzunluğundaki alanda yürüyerek, dakikadaki kalp hızı ve yürüme mesafeniz kaydedilecektir.Çalışmamızda olgular randomize (rastgele) olarak iki gruba ayrılacaktır. Bu gruba (Grup 2) aerobik egzersiz programına ek olarak rezistif (dirençli) egzersiz programına alınacaktır. Bu eğitim kapsamında öncelikle koşu bandında 5 er dakika ısınma ve soğuma periyodu ile birlikte 30 dk normal kalp hızında yürüme (aerobik egzersiz) ve lastik dirençli bantlar ile (teraband) ile oturma pozisyonunda ayak bileği eklemi hareketleri, diz eklemi hareketleri 8 tekrarlı 2 set ile ayakta durma pozisyonunda kalça eklemi hareketleri rezistif(dirençli) egzersiz olarak 8 tekrarlı 2 set olmak üzere uygulanacaktır. Haftada 1 gün bu uygulama ev egzersiz programı olarak verilecektir. 6 haftanın sonunda ön testler tekrarlanarak, ölçümler kayıt edilecektir.

Araştırmada yapılan değerlendirmelerin sonuçları yalnızca araştırma kapsamındaki çalışmalarda kullanılacaktır. Kişisel bilgileriniz herhangi bir amaçla, kurum yöneticileri veya üçüncü kişilerle paylaşılmayacaktır. Katılımınız için teşekkür ederiz.

Sorumlu Araştırmacı: Fzt. Güzin Kaya Aytutuldu- 05366265884

"**Tip 2 Diyabetli Hastalarda Resistif Egzersiz ya da Propriyoseptif Egzersiz Eğitiminin Denge ve Yüzeysel Duyu Üzerine Etkileri" ni** incelemek amacıyla yapılan bu çalışmaya hiçbir baskı ve zorlama olmaksızın kendi rızamla katılmayı kabul ediyorum.

Gönüllünün Adı / Soyadı / İmzası / Tarih

Açıklamaları Yapan Kişinin Adı / Soyadı / İmzası / Tarih

APPENDIX 2: STRUCTURED QUESTIONNAIRE

Yeditepe Üniversitesi

Sağlık Bilimleri Enstitüsü

Fizyoterapi ve Rehabilitasyon Anabilim Dalı

Bölüm 1. Demografik Özellikler Tarih :…/….. /……

1) Hastanın Adı Soyadı: …… Telefonu:

2) Yaş: HBA1C: Açlık Kan Glikozu:

3) Cinsiyet: ( ) Kız ( ) Erkek

4) Boy uzunluğu (cm):

5) Vücut ağırlığı (kg) :

6) Dominant taraf: El ( ) sağ ( ) sol

Ayak ( ) sağ ( ) sol

7) Medeni Durumunuz: ( ) Hiç evlenmemiş ( ) Evli

( ) Boşanmış ( ) Ayrı yaşıyor

( ) Eşi ölmüş

8) Eğitim durumunuz

Okuryazar değil ☐
İlköğretim ☐
Lise ☐
Üniversite ve üzeri ☐

8) Mesleğiniz:

9) Maddi durumunuz:

1000TL'den az ☐ 1000-2000TL ☐ 2000-3000TL ☐ 3000TL ve üzeri ☐

10) Sosyal güvenceniz:
Var ☐ Yok ☐

11) Çocuğunuz: ( ) var ( ) yok Varsa kaç çocuğunuz var.....

12) a) Sigara kullanıyor musunuz?

( ) Hiç içmedim ( )Sigara içtim ama bıraktım ( )Halen içiyorum

b) Günde kaç adet sigara içiyorsunuz?.....adet/gün

Sigara: .....Paket/Yıl

13) Alkol kullanıyor musunuz? ( ) Evet ( ) Hayır

Hangi sıklıkla?.....

14) Gözlük kullanıyor musunuz? ( )Evet ( ) Hayır

15) Herhangi bir sürekli hastalığınız (diyabet dışında) var mı? Varsa hangileri?

( ) Sürekli bir hastalığım yok

( ) Romatizma ( ) Ortopedik hastalık ( ) Nörolojik problemler

( ) Travma ( ) Diğer.....

16)Diyabet Tipi: ( ) Tip 1 ( ) Tip 2

17) Kaç yılında diyabet tanısı aldınız?.....

18) Kullandığınız ilaçlar nelerdir?.....

19) Kullandığınız ilaçların dozu nedir? ...../Günde ...../Haftada

20)İnsülin kullanıyor musunuz? ( ) Evet ( ) Hayır

Evet ise ne zamandır?..... Dozu nedir?.....

21) Merkezde diyabet eğitimlerinden hangilerini aldınız?

( ) Temel diyabet eğitimi ( ) Diyabetin Komplikasyonları

( ) Beslenme Eğitimi ( ) Kan şekeri Takibi

( ) İnsülin Eğitimi ( ) Hipoglisemi-Hiperglisemi Eğitimi

( ) Gestasyonel Diyabet Eğitimi ( ) Diyabette Egzersizin Önemi

( ) Ayak Bakım ve Önemi ( ) Diyabet Genel Sağlık Önerileri Diğer.....

22) Ailenizde yatkınlığı bulunan hastalık var mı ? ( ) Evet ( ) Hayır

Evet ise..... ( ) Diyabet ( ) Kalp Hastalığı ( ) Hipertansiyon Diğer.....

Kim?..... ( ) Anne ( ) Baba ( ) Kardeş Diğer.....

23)Şu an herhangi bir ağrı kesici ilaç kullanıyor musunuz? ( ) Evet ( ) Hayır

Evet ise ne zamandır?.....

24)Herhangi bir ameliyat geçirdiniz mi? ( ) Evet..... Belirtiniz ( ) Hayır

25)Hiç kaza gecirdiniz mi ? ( ) Evet.....Belirtiniz ( ) Hayir

26)Spor yapıyor musunuz? Yapıyorsanız ne sıklıkta?

( ) Yapmıyorum

( )Ayda bir kez den az ( )Ayda 2 kez ve fazla ( )Haftada 1 kez

( )Haftada 2-3kez ( )Haftada 4-5 kez ( )Her gün

27) (Egzersiz yapanlar için) Yaptığınız egzersiz her seferinde kaç dakika sürüyor

( )20 dk az ( )20-30 dk ( )30 – 60 dk ( )60 dk. dan fazla

28) Vücudunuzda ağrı hissediyor musunuz?

Nerede ?

Ne zamandır?

VAS 0_____ 10

İstirahat

VAS 0_____10

Hareket

VAS 0_____10

Gece

Bölüm 2.Antropometrik Ölçümler

	İlk	**Son**
Bel Çevresi		
Kalça Çevresi		
Bel/Kalça Oranı		
BMI		

Bölüm 3.Kardiyovasküler parametreler

	İlk	Son
Kalp Hızı		
Kan Basıncı (sistolik/diastolik)		
Kan Glikoz Seviyesi		
Oksijen Saturasyonu		

Bölüm 4.Denge Değerlendirmesi (Prokin)

	Bipedal (ilk)	Bipedal (son)
Perimeter Length (PL)		
Area Gap percentage (AGP)		
Medspeed (MS)		
Anterior-posterior Sway (AP)		
Mediolateral sway (ML)		

Bölüm 5. Proprioception Değerlendirmesi

	Sağ		Sol	
	ilk	**son**	**İlk**	**Son**
Dorsi fleksiyon açısı:				
Plantar fleksiyon açısı:				

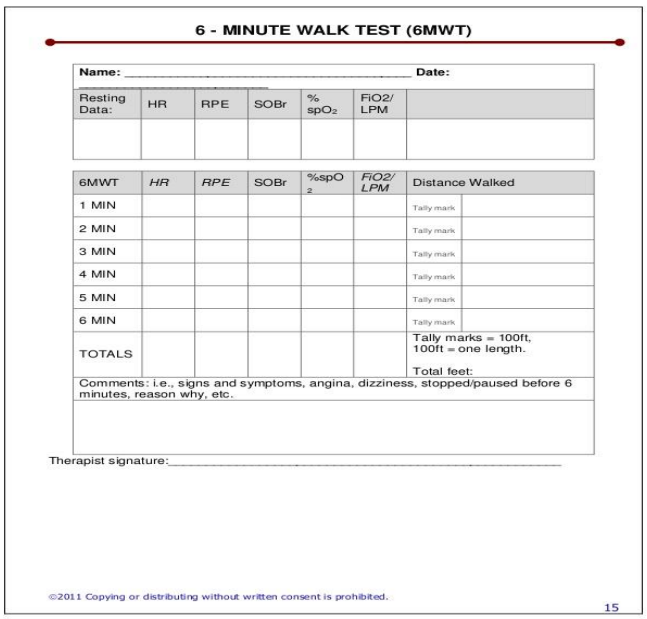
Bölüm 6. Duyu Değerlendirmesi

	İlk	Son
İki Nokta Diskriminasyonu		
Vibrasyon		

Bölüm 7. Kas Kuvveti Değerlendirmesi

İlk Değerlendirme			Son Değerlendirme		
	SAĞ	SOL		SAĞ	SOL
Ayak Bileği DF			Ayak Bileği DF		
Ayak Bileği PF			Ayak Bileği PF		
Quadriceps			Quadriceps		
Hamstring			Hamstring		
Kalça Abduktorleri			Kalça Abduktorleri		
Kalça Adduktorleri			Kalça Adduktorleri		
Kalça Flexorleri			Kalça Flexorleri		
Kalça Extensorleri			Kalça Extensorleri		

Bölüm 8. 6 Dakika Yürüme Testi



6 - MINUTE WALK TEST (6MWT)

Name: _____ Date: _____

Resting Data:	HR	RPE	SOBr	% spO_2	FiO2/ LPM	

6MWT	*HR*	*RPE*	SOBr	%spO_2	*FiO2/ LPM*	Distance Walked
1 MIN						Tally mark
2 MIN						Tally mark
3 MIN						Tally mark
4 MIN						Tally mark
5 MIN						Tally mark
6 MIN						Tally mark
TOTALS						Tally marks = 100ft, 100ft = one length. Total feet:

Comments: i.e., signs and symptoms, angina, dizziness, stopped/paused before 6 minutes, reason why, etc.

Therapist signature:_____

15

APPENDIX 3: PERMISSION LETTER FROM THE INSTITUTION

T.C.
PENDİK BELEDİYE BAŞKANLIĞI
Kültür İşleri Müdürlüğü

Sayı : 50878946-622.01-E.1941 05/12/2016
Konu : Yüksek Lisans Tez Araştırması İzni

Sayın GÜZİN KAYA AYTUTULDU
İçerenköy Mahallesi Engin Sokak No:2 Güldehan Apartmanı Kat:6 D:14 Ataşehir / İSTANBUL

İlgi : 01/12/2016 tarihli dilekçeniz.

İlgi tarihli dilekçenizde Bahçeşehir Üniversitesi Klinik Araştırmalar Etik Kurulu Başkanlığına verilmek üzere "Tıp 2 Diyabetli Hastalarda Rezistif Egzersiz veya Propriyoseptif Egzersiz Eğitiminin Denge ve Yüzeyel Duyu Üzerine Etkileri" isimli yüksek lisans tez araştırmanızı Arif Nihat Asya Kültür Merkezinde uygulamanız konusunda izin talep etmektesiniz.

Kurumumuzca söz konusu yüksek lisans tez araştırmanızı Arif Nihat Asya Kültür Merkezinde uygulamanızda herhangi bir sakınca bulunmadığı hususunu;

Bilgilerinize arz ederim.

Nuri SİNCANLI
Belediye Başkanı a.
Kültür İşleri Müdürü

05/12/2016 Bölüm Sorumlusu : Faruk ERDOĞAN

5070 sayılı kanun gereğince E-İMZA ile imzalanmıştır. [R:111661701]

Batı Mah. 23 Nisan Cad. No:11 34890 Pendik/İSTANBUL
Telefon: 444 81 80 Faks: (0 216) 585 14 71
tsiren@pendik.bel.tr Elektronik Ağ: www.pendik.bel.tr
00.FR.12

APPENDIX 4 : ETHICAL COMMITTEE APPROVAL

T.C.
BAHÇEŞEHİR ÜNİVERSİTESİ REKTÖRLÜĞÜ
Klinik Araştırmalar Etik Kurulu

Sayı : 22481095-020-1323 19/12/2016

Konu : Karar Örneği

SAYIN GÜZİN KAYA AYTUTULDU

Sorumlu araştırmacısı olduğunuz "Tip İki Diyabetli Hastalarda Rezistif Egzersiz veya Propriyoseptif Eğitiminin Denge ve Yüzeysel Duyu Üzerine Etkileri" isimli çalışmanız ile ilgili Klinik Araştırmalar Etik Kurulu karar örneği ektedir.

Gereğini bilgilerinize rica ederim.

Prof.Dr. Nazire Efser Yeşim AFŞAR
FAK
Komisyon Başkanı

/ 1
Pin :

Telefon:2165798210 Fax:
İrtibat Email: nurcan.vatansever@bahcesehir.edu.tr
Ayrıntılı bilgi için irtibat:Nurcan VATANSEVER
Elektronik Ağ: www.bahcesehir.edu.tr

BAHÇEŞEHİR ÜNİVERSİTESİ
KLİNİK ARAŞTIRMALAR ETİK KURULU

Üniversitemiz Klinik Araştırmalar Etik Kurulu'na ait 07 Aralık 2016 Tarih ve 2016-10/04 Sayılı Karar Örneğidir.

KARAR:2016-10/04

Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Fizyoterapi ve Rehabilitasyon Anabilim Dalı Yüksek Lisans Öğrencisi Güzin KAYA AYTUTULDU'nun **"Tip İki Diyabetli Hastalarda Rezistif Egzersiz Veya Propriyoseptif Egzersiz Eğitiminin Denge ve Yüzeysel Duyu Üzerine Etkileri"** isimli çalışmasının başvuru dosyası görüşüldü.

Görüşmeler sonunda Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Fizyoterapi ve Rehabilitasyon Anabilim Dalı Yüksek Lisans Öğrencisi Güzin KAYA AYTUTULDU'nun **"Tip İki Diyabetli Hastalarda Rezistif Egzersiz Veya Propriyoseptif Egzersiz Eğitiminin Denge ve Yüzeysel Duyu Üzerine Etkileri"** isimli çalışmaları gerekçe, amaç, yaklaşım ve yöntemleri dikkate alınarak; incelenmiş ve uygun bulunmuş olup araştırmanın/çalışmanın başvuru dosyasında belirtilen merkezlerde gerçekleştirilmesinde etik ve bilimsel sakınca bulunmadığına karar verildi.

Prof.Dr. Nazire AFŞAR
Etik Kurul Başkanı

APPENDIX 5 : EXERCISE EDUCATION BROCHURE

DİKKAT: Bu belirtiler görülürse egzersizi sonlandırmalıyız !

Terleme ve Titreme

Solgunluk

Aşırı açlık

Kalp Çarpıntısı

Göz bebeklerinin aşırı büyü-mesi

Bilinç Bulanıklığı

Koordinasyon Bozukluğu

Konuşma Zorluğu

KAN ŞEKERİNİZ 250 MG/DL ÜZERİNDEYSE VE 100 MG/DL ALTINDAYSA İDRARINIZDA KETON VARSA EGZERSİZ YAPMAYINIZ.

Yeditepe Üniversitesi Sağlık Bilimleri Fakültesi Fizyoterapi ve Rehabilitasyon Bölümü

Fzt.Güzin KAYA AYTUTULDU

E-mail: guzinkaya14@gmail.com

GSM: 05366265884

DİYABET VE EGZERSİZ

DİYABET VE EGZERSİZ

Diyabet tedavisinde; tıbbi beslenme tedavisi, ilaç tedavisi ve egzersiz (fiziksel aktivite) ayrılmaz üçlüdür.

Egzersiz en az beslenme ve ilaç tedavisi kadar önemlidir. Özellikle, tip 2 diyabetli hastalarda fiziksel aktivitenin arttırılması, şekerin hücreler tarafından kullanılmasını hızlandırır ve kan şekerini düşürücü yönde etki yapar.

EGZERSİZİN FAYDALARI

*İnsülin hassasiyetini arttırır.

*Kan şekeri kontrolü daha kolay sağlanır.

*Kalp damar hastalıkları riskini azaltır.

*Kasları kuvvetlendirir. Kemik yoğunluğunu arttırır.

*Kan dolaşımını ve oksijen tüketimini arttırır.

*Stresi azaltır ve gevşemenizi sağlar.

EVDE YAPABİLECEĞİNİZ ÖRNEK EGZERSİZLER

Tenis topu ya da tırtıklı bir topu ayağınızın altında yuvarlayın

Topuklarınızı hareket ettirmeden ayak parmaklarınızla çarşafı toplayın

Renkli Dirençli bantlar kullanarak ayak bileğinizi öne ve geriye hareket ettiriniz. Eğer bant bulamazsanız aktif olarak ayağınızı öne-geriye hareket ettirebilirsiniz .

Kişiye özel egzersiz programınız için fizyoterapistinize danışabilirsiniz

Renkli bantları iki elinizle tutarak birbirinden uzaklaştırınız . Düz bir çizgide yürümeye çalışarak dengenizi geliştirebilirsiniz.

Aerobik Egzersiz

*Kaslarınızı çalıştırır

*Nefes alıp verme sayısını artırır.

*Egzersiz aşırı yorgunluğa neden olmamalı fakat kişinin kalp hızını arttıracak tempoda olmalıdır.

*Doğru tempoda egzersiz yapan birey, nefes nefese kalmadan konuşabilmeli, ancak solunum temposu şarkı söylemeye yetmemelidir

(Örneğin bir otobüsü yakalamak amacıyla yapılan hızlı yürüyüş temposu)

Örnek Aerobik Egzersizler

- Hafif tempolu yürüyüş yapın
- Dans edin
- Hafif şiddetli aerobik egzersiz programlarına katilin
- Yüzün yada suda aerobik egzersizler yapın

ÖZGEÇMİŞ

1. Adı Soyadı **:** Güzin KAYA AYTUTULDU

İletişim Bilgileri
Adres **:** Kayışdağı Yolu Cad. Engin Sok. Güldehan Hanım Apt. K:6 D:14 Ataşehir / İSTANBUL

Telefon **:** 0536 626 58 84
Mail guzinkaya14@gmail.com

2. Doğum Tarihi **:11.09.1992**

3. Unvanı **:Fizyoterapist**

4. Öğrenim Durumu **:Yüksek Lisans**

Derece	Alan	Öğrenim Yeri	Yıl	Not Ortalaması
Lise	Sayısal Alan	Adana Anadolu Lisesi	2010	85.67 / 100
Lisans	Fizyoterapi ve Rehabilitasyon (İngilizce)	Yeditepe Üniversitesi	2015-Ocak	3.59/ 4.00
Yüksek Lisans	Fizyoterapi ve Rehabilitasyon	Yeditepe Üniversitesi	Tez aşamasında	

5.Yüksek Lisans Tezi

Tip 2 diyabet hastalarında propriyoseptif egzersiz eğitimi veya rezistif egzersiz eğitiminin denge ve yüzeyel duyu üzerine etkileri

6.Projeler

6.1. Job Coaching Training:Place, Train, Maintain for People with Intellectual Disabilities, Erasmus Plus Yetişkin Eğitimi Projesi.

7.Sertifika ve Katılan Kurslar

7.1.Üst ,alt ekstremite ve omurga maniplasyon ve mobilizasyon kursu, Osman ŞAHİN 13-14 Aralık 2014
7.2. Kinezyolojik Bantlama , Osman ŞAHİN 20-21 Aralık 2014

7.3. Visceral Diagnosis and Treatment Course on Lumbosacral and Hip Joint Disorders Course, 10-12 March 2017, Yeditepe University, Istanbul.

8. Diğer Faaliyetler

8.1 II. Yeditepe Fizyoterapi ve Rehabilitasyon Sempozyumu, 11-12 Şubat 2014 (Düzenleme Kurulu)

8.2. II. Yeditepe Fizyoterapi ve Rehabilitasyon Sempozyumu, 11-12 Şubat 2014 (Sempozyum Sekreteryası)

8.3. Yeditepe Üniversitesi'nde düzenlenen 19th International Symposium of Adapted Physical Activity (19-23 July 2013)- (Volunteer Student).

8.4 Job Coaching Training:Place, Train, Maintain for People with Intellectual Disabilities, Erasmus Plus Yetişkin Eğitim Projesi kapsamında düzenlenen workshop 31 Mayıs- 5 Haziran 2015

Akademik Eğitim Faaliyetleri

Kod	**Dersin Adı**	**Asistanı (Arş. Gör.)**	**Dönemi**
PTR 314 (Lisans)	Nörolojik Rehabilitasyon	Fzt.Sevgi Gamze FELEK Fzt.Güzin KAYA	2015 Bahar
PTR 206 (Lisans)	Elektro terapi	Fzt.Elif ÜSTÜN Fzt.Güzin KAYA	2015 Bahar
PTR 402 (Lisans)	Klinik çalışma (Staj) II	Fzt.Elif Üstün Fzt. Güzin Kaya	2015 Bahar
PTR 301 (Lisans)	Nörofizyolojik Yaklaşımlar-I	Fzt.Güzin KAYA	2015 Güz
PTR 302 (Lisans)	Nörofizyolojik Yaklaşımlar- II	Fzt.Güzin KAYA	2016 Bahar
PTR 314 (Lisans)	Nörolojik Rehabilitasyon	Fzt.Güzin KAYA	2016 Bahar
PTR 301	Nörofizyolojik Yaklaşımlar-I	Fzt.Güzin KAYA AYTUTULDU	2016 Güz
PTR 211	Nöroanatomi	Fzt.Güzin KAYA AYTUTULDU	2016 Güz

Yayınlar:

A.Uluslararası Diğer Hakemli Dergilerde Yayınlanan Makaleler (Index Copernicus International)

B-Uluslararası Hakemli Dergilerde Yayınlanan Makaleler