ผลของการออกกำลังกายแบบไทจี๋ฉวนต่อการควบคุมระดับน้ำตาลในเลือด และสมรรถนะทางแอโรบิคในผู้ป่วยเบาหวานชนิดไม่พึ่งอินสุลิน

พันตำรวจตรีหญิง ฉวีวรรณ ดีช่วย

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต

หลักสูตรสาขาวิชาเวชศาสตร์การกีฬา

คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ปีการศึกษา 2542

ISBN 974-334-424-1

EFFECT OF TAI CHI CHAUN EXERCISE ON GLYCEMIC CONTROL AND AEROBIC CAPACITY IN NIDDM PATIENTS

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A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science in Sports Medicine

Program of Sports Medicine

Faculty of Medicine

Chulalongkorn University

Academic Year 1999

ISBN 974-334-424-1

Thesis Title	**EFFECTS OF TAI CHI CHAUN EXERCISE ON GLYCEMIC CONTROL AND AEROBIC CAPACITY IN NIDDM PATIENTS**
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ฉวีวรรณ ดีช่วย: ผลของการออกกำลังกายแบบไทจี๋ฉวนต่อการควบคุมระดับน้ำตาลในเลือดและสมรรถนะทางแอโรบิคในผู้ป่วยเบาหวานชนิดไม่พึ่งอินสุลิน (EFFECT OF TAI CHI CHAUN EXERCISE ON GLYCEMIC CONTROL AND AEROBIC CAPACITY IN NIDDM PATIENTS) อ. ที่ปรึกษา : ผศ. นพ. สมพงษ์ สุวรรณวลัยกร, อ. ที่ปรึกษาร่วม : ผศ. นพ. สมพล สงวนรังศิริกุล, 74 หน้า. ISBN 974-334-424-1

การออกกำลังกายแบบไทจี๋ฉวนหรือไท้เก็กปัจจุบันได้รับความนิยมเพิ่มมากขึ้นในประเทศไทยเพราะเป็นการออกกำลังกายที่ไม่ต้องใช้พื้นที่กว้าง ไม่ต้องอาศัยอุปกรณ์ที่มีราคาแพงประกอบกับเป็นการออกกำลังกายที่มีท่วงท่าการเคลื่อนไหวของร่างกายที่ประสานสอดคล้องกันกับการหายใจไปอย่างต่อเนื่องและมีสมาธิ วัตถุประสงค์ของการศึกษาครั้งนี้เพื่อศึกษาผลของการออกกำลังกายแบบไทจี๋ฉวนต่อการควบคุมระดับน้ำตาลในเลือดและสมรรถนะทางแอโรบิค ในผู้ป่วยเบาหวานชนิดไม่พึ่งอินสุลิน (ชนิดที่ 2) จำนวน 16 คน (ผู้หญิง 11 คน ผู้ชาย 5 คน อายุเฉลี่ย 58.81$\pm$5ปี) ที่ไม่ได้ออกกำลังกายเป็นประจำ ให้รับประทานยาหรือฉีดยารักษาเบาหวานตามปกติ และไม่มีการจำกัดจำนวนหรือชนิดของอาหารตลอดการทดลอง โดยให้ออกกำลังกายแบบไทจี๋ฉวนครั้งละประมาณ 1 ชั่วโมง สัปดาห์ละ 3 วันเป็นเวลา 16 สัปดาห์ การทดสอบประกอบด้วย การวัดน้ำหนักตัว เปอร์เซ็นต์ไขมันในร่างกาย ความอ่อนตัว ระดับน้ำตาลในเลือดระยะอดอาหาร ระดับน้ำตาลสะสม ระดับไขมันในเลือดและทดสอบสมรรถภาพของระบบหัวใจและการหายใจในช่วงสัปดาห์แรก สัปดาห์ที่ 8 และสัปดาห์สุดท้าย

ผลการทดลองพบว่ากลุ่มตัวอย่างมีค่าความอ่อนตัวดีขึ้น 34 เปอร์เซ็นต์ในสัปดาห์ที่ 8 และ 60 เปอร์เซ็นต์ในสัปดาห์ที่16 ผลของระดับน้ำตาลในเลือดระยะอดอาหารลดลง 15 เปอร์เซ็นต์ และระดับน้ำตาลสะสมลดลง 13 เปอร์เซ็นต์ เมื่อเปรียบเทียบกับก่อนการออกกำลังกายอย่างมีนัยสำคัญทางสถิติ ($p<0.05$ และ $p< 0.01$ ตามลำดับ) ไม่มีการเปลี่ยนแปลงอย่างมีนัยสำคัญทางสถิติของน้ำหนักตัว เปอร์เซ็นต์ไขมันในร่างกายและระดับไขมันในเลือด เมื่อทำการทดสอบสมรรถนะของระบบหัวใจและการหายใจ ที่ระดับการออกกำลังสูงสุดพบว่าค่าอัตราการใช้ออกซิเจนสูงสุดเพิ่มขึ้น 10 เปอร์เซ็นต์และงานที่ทำได้สูงสุดเพิ่มขึ้น 12 เปอร์เซ็นต์ ($p<0.05$) ส่วนที่ระดับความหนักของการออกกำลังที่ทำให้เกิดการสะสมกรดแลคติคในเลือด พบว่ามีค่าอัตราการใช้ออกซิเจนเพิ่มขึ้น12เปอร์เซ็นต์ และ 55 เปอร์เซ็นต์ ($p<0.05$) ของงานที่ทำได้ ขณะออกกำลังกายอัตราการเต้นของหัวใจประมาณ 70 เปอร์เซ็นต์เมื่อเปรียบเทียบกับอัตราการเต้นของหัวใจสูงสุดที่ได้จากการทดสอบการออกกำลังกายซึ่งจัดเป็นการออกกำลังกายที่มีความหนักระดับปานกลาง

การศึกษานี้แสดงให้เห็นว่า การออกกำลังกายแบบไทจี๋ฉวนอย่างสม่ำเสมอต่อเนื่อง สามารถช่วยควบคุมระดับน้ำตาลในเลือดได้ และทำให้ผู้ป่วยมีร่างกายแข็งแรง ระบบการทำงานของระบบหัวใจ การหายใจ ดีขึ้น ไทจี๋ฉวนจึงอาจใช้เป็นรูปแบบของการออกกำลังกายที่ปลอดภัยชนิดหนึ่งและเหมาะสมในการแนะนำให้ผู้ป่วยนำไปปฏิบัติ

ภาควิชา.................................. **ลายมือชื่อนิสิต** ฉวีวรรณ ดีช่วย

สาขาวิชา เวชศาสตร์การกีฬา **ลายมือชื่ออาจารย์ที่ปรึกษา** ....

ปีการศึกษา 2542 **ลายมือชื่ออาจารย์ที่ปรึกษาร่วม** สมพล สงวนรังศิริกุล

3970338330 : MAJOR SPORTS MEDICINE

KEY WORD: TAI CHI CHAUN / GLYCEMIC CONTROL / NIDDM PATIENT

CHAWEEWAN DEECHAUY : EFFECT OF TAI CHI CHAUN EXERCISE ON GLYCEMIC CONTROL AND AEROBIC CAPACITY IN NIDDM PATIENTS. THESIS ADVISOR : ASSIST. PROF. SOMPONG SUWANWALAIKORN, M.D., THESISCOADVISOR : ASSIST. PROF. SOMPOL SA-NGUANRUNGSIRIKUL,M.D.

74 pp. ISBN 974-334-424-1.

Tai Chi Chaun (TCC), a traditional Chinese conditioning exercise, has been widely practiced in Thailand. It requires only little space and no expensive equipment. During the performance of TCC, mind concentration and breathing control are integrated with graceful body movement. The objective of this study was to determine the effect of TCC exercise on glycemic control and aerobic capacity in NIDDM (type 2) patients. Sixteen participants (11 women and 5 men, mean age 58.81±5 yr) were sedentary, type 2 diabetics, on an oral hypo-glycemic drug, insulin, and no specified diet regimen at study onset and throughout this period. Exercise TCC about 1 hour thrice per week for 16 weeks. Body weight, percent body fat, flexibility, fasting plasma glucose (FPG), glycosylated hemoglobin (HbA1c), lipid profile, and cardiorespiratory fitness were evaluated at baseline (first week), in the middle (8 week), and at the end (16 weeks) of TCC program.

The result showed that 34 per cent significantly increase in flexibility at eighteenth weeks and 60 per cent of TCC exercise at sixteenth weeks in comparison with a first week ($p<0.05$). FPG and HbA1c significantly decrease 15 per cent ($p<0.05$) and 13 per cent ($p<0.01$), respectively from baseline to sixteen weeks. No significant change was found in body weight, percent body fat, lipid profile. In addition, these subjects showed 10 per cent significantly increase in VO_2peak and 12 per cent increase in peak work rate at the peak exercise ($p<0.05$). At the ventilatory threshold, the increment of 12 per cent was found in VO_2 and 55 per cent in work rate ($p<0.05$) in comparison between first week and sixteenth weeks. Exercise intensity was estimated to 70 per cent of maximal heart rate from peak exercise test, which corresponds to moderate exercise intensity.

In conclusion, the regular TCC exercise could improve diabetic controls and physical fitness. It is safe effective, suitable and could be a choice of exercise therapy to recommend for elderly diabetes.

ภาควิชา.................................ลายมือชื่อนิสิต ฉวีวรรณ ดีช่วย

สาขาวิชา เวชศาสตร์การกีฬา ลายมือชื่ออาจารย์ที่ปรึกษา.............................

ปีการศึกษา 2542 ลายมือชื่ออาจารย์ที่ปรึกษาร่วม.............................

ACKNOWLEDGEMENTS

I am indebted to my subjects for highly enthusiastic participation in this project.

I would like to express my whole hearted thanks and gratitude to my advisor, Assistant Professor Dr. Sompong Suwanwalaikorn, my co-advisor, Assistant Professor Dr. Sompol Sa-nguanrangsirikul and Professor Ratree sudsuang for their valuable advice, helpful guidance, encouragement and long lasting support throughout this study.

I also thank Mrs. Sopitsagee Pasatrat and an Abbott Laboratories Company for the hematology measurements and allowing the use of the blood glucose monitoring equipment.

I warmly thank Miss Jirapa Nakanakup, Miss Jarintip Kongsakpronchai, Miss Supa Jomjang, all my friends in program of Sports Medicine and the Department of Physiology, Faculty of Medicine Chulalongkorn University for their assistance, sincerity, friendship and cheerfulness.

Finally, I also wish to express extra special thanks to my parent and my office for their infinitive love, kindness and understanding giving to me though my graduate study.

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LIST OF ABBREVIATIONS

ACSM	American College of Sports Medicine
A.D.	Anno domini
ADA	American Diabetes Association
BW	Body weight
% BF	Percentage of body fat
°C	Degree Celsius
cm	Centimeter
Chol	Cholesterol
Chol/HDL	Cholesterol / high density lipoprotein
CO2	Carbon dioxide gas
DM	Diabetes mellitus
e.g.	Exempli gratia
FPG	Fasting plasma glucose
HbA1c	Glycosylate hemoglobin
HDL	High density lipoprotein
HR	Heart rate
i.e.	Id est
Kg	Kilograms
L	Liter
mg/dl	Milligram / deciliters
min	Minute

ml	Milliliter
O_2	Oxygen gas
OPD	Outpatient department
$P_{ET}CO2$	End tidal carbon dioxide concentration
$P_{ET}O2$	End tidal oxygen concentration
R	Respiratory exchange ratio
SD	Standard deviation
TCC	Tai Chi Chaun
TG	Triglyceride
VC	Vital capacity
V_E	Minute ventilaion
V_E/VCO_2	Ventilatory equivalent for carbon dioxide
$V_E/VO2$	Ventilatory equivalent for oxygen
VeT	Ventilatory threshold
VO_2	Oxygen uptake
VO_2max	Maximum oxygen uptake
WHO	World Health Organization
WR	Work rate
yr	Year

CHAPTER I

INTRODUCTION

There are about 154 million people with diabetes worldwide in the year 2000. This number is predicted to rise almost 300 million by the year 2025. More than 50 percent of people with diabetes in 2010 will be in Asia (1 in every 2 person with diabetes will be Asian). Southeast Asia will be one of the region with large number of people with diabetes, approximately 80 million. Two main forms of diabetes are type 1 and type 2. It is estimated that up to 90 percent of diabetic patients have type 2 diabetes and by the year 2010 there will be more than 215 million of these patients worldwide (Figure 1.1)

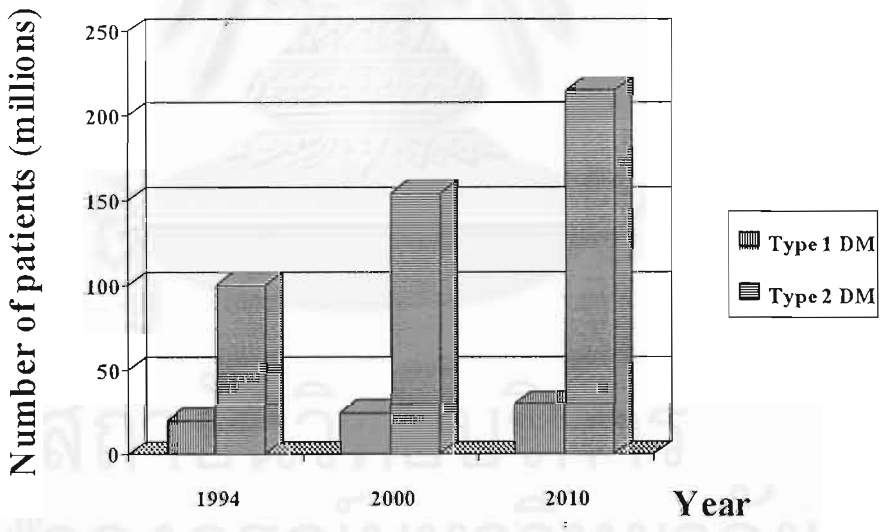


Figure 1.1 Estimates of the worldwide incidence of diabetes (Amos et al, 1997; WHO, 1998).

Diabetes mellitus is associated with a high rate of morbidity and mortality, the increasing prevalence is likely to place a high economic burden on healthcare resources. This alarming increase in patient numbers has raised awareness of the need for more precise treatment guidelines, with the aim of lowering blood glucose concentrations. Thus, the prevention and control of diabetes is now recognized as an urgent priority (Amos et al., 1997; Jorgensen et al., 1999).

A. Classification of diabetes mellitus (DM)

The old treatment-based classification has been rendered obsolete by advances in etiology. There are 4 categories in the new classification, type 1 and 2 broadly correspond to what was previously know as IDDM and NIDDM, respectively, type 3 cover other specific types, and type 4 relates to gestational diabetes (ADA, 1997).

Type 1 diabetes is defined as β-cell destruction usually leading to absolute insulin deficiency. It is further sub-divided into immunemediated or idiopathic disease.

Type 2 diabetes may range from predominantly insulin resistance with relative insulin deficiency to predominantly secretory defect with insulin resistance.

Insulin-resistance is defined as the reduce ability of insulin to exert its usual biological actions, e.g. the suppression of hepatic glucose production, at circulating concentrations which are effective in normal individuals. It can effect the whole body, but skeletal muscle, adipocytes and the liver are particularly affected in Type 2 diabetes. Insulin resistance also develops as a result of elevated blood levels, and hyperglycemia itself may impair insulin-mediated glucose transport.

B. Diabetes Mellitus in Thailand

1. Prevalence of diabetes mellitus (DM) in Thailand

The National Health Examination Survey (NHES) in Thailand in 1996 showed that the overall prevalence of diabetes was 2.3 percent by using fasting plasma glucose (FPG) of ≥ 140 mg/dl as criterion for diagnosis (Table 1.1)(NHES, 1996). Approximately one half of the cases (42.6 percent) were known diabetes. It was demonstrated by this survey that the prevalence rate of diabetes, which rose with age was higher in urban populations and in female subjects.

Table 1.1 Prevalence of diabetes mellitus by age, sex and residential area in NHES study of Thai Health Research Institute (NHES, 1996).

Age(years)	Prevalence of DM in urban(%)		Prevalence of DM in rural (%)	
	male	female	male	female
15-24	0.7	0.2	0.6	0.2
25-34	0.2	2.0	1.2	0.7
35-44	1.4	1.6	1.0	1.7
45-54	5.5	6.3	1.4	4.5
55-64	6.4	8.8	2.7	4.1
65 +	4.0	8.8	4.2	3.6
Total	2.6	2.9	1.5	1.9

2. Types

Majority of Thai patients was type 2 DM. Study in three diabetes clinics revealed that in clinic populations, 95- 96.3 per cent were type 2 patients. Type 1 diabetes accounted for 1.5-4 percent, the rest (1-2 percent) were other types of diabetes (Nitiyanant , 1999).

C. Type 2 DM

1. Pathophysiology

The hormone, insulin, maintains normal blood glucose levels by regulating glucose formation by the liver, as well as glucose uptake by peripheral tissue. Hyperglycemia in type 2 diabetic patients develops as result of deficient insulin secretion and/or resistance to the actions of insulin. Insulin resistance is generally recognised as the primary pathophysiological feature. A genetic influences the pathogenesis of type 2 diabetes (Flatt, 1997; Reaven, 1998). However, environmental factors associated with obesity, such as a high-calorie diet and lack of physical exercise, may also induce the development of disease in susceptible individuals (Bowen and Gill, 1997; Matsuoka, 1999).

2. Symptoms

The onset of symptoms is usually insidious and patients may be hyperglycemic for several years before diabetes is diagnosed. Symptoms of marked hyperglycemia include polyuria, polydipsia, weight loss, sometimes with polyphagia, and blurred vision. Impairment of growth and susceptibility to certain infections may also accompany chronic hyperglycemia. Acute, life-threatening consequences of diabetes are hyperglycemia with ketoacidosis or the nonketotic hyperosmolar syndrome (ADA, 1997).

3. Complications

Diabetes-related microvascular and cardiovascular complication reduce the quality of life and shorten life span by as much as 8-10 years (Glasgow, 1997; Ganda, 1999). The chronic hyperglycemia of diabetes is associated with long-term damage, dysfunction, and failure of a various organs, especially the eyes, kidneys, nerves, heart, and blood vessels (Alberti and Zimmet, 1998).

4. Aims of treatment

The treatment goal in type 2 diabetic patients is to improve glycemic control. Ideally, the aim of therapy is the normalization of blood glucose levels.

An additional marker of a patient's glycemic state is the level of glycosylated hemoglobin (HbA_1c), which is formed by the adduction of glucose to hemoglobin. HbA_1c is thought to reflect integrated blood glucose concentration over a period of 2 months, i.e. the approximate half-life of red blood cells (McCance and Kennedy, 1991). Therefore, HbA_1c give a more accurate indication of long-term glycemic control than random blood glucose measurements, which may be influenced by a number of factors such as the diurnal glycemic profile, and food intake of fasting prior to analysis. Current targets for glycemic control are detailed in Table 1.3 (ADA, 1998).

***Table 1.3 American Diabetes Association Glycemic control** (ADA, 1998).*

Biochemical Index	Normal	Goal	Additional Action Suggested
Fasting/preprandial glucose	**<115**	**80-120**	**<80 or >140**
	(< 6.0)	(< 6.6)	(<4.4 or >7.8)
Bedtime glucose	**<120**	**100-140**	**<100 or > 160**
HbA_1c(%)	**< 6**	**< 7**	**> 8**

Data are mg/dl (mmol/l). Glycated hemoglobin is referenced to a nondiabetic range of 4-6 %

5. Monitoring

Monitoring of type 2 DM by both patient and physician is the key to good management. It used to assess the efficacy of the therapy and to guide adjustments in exercise and medication to achieve the best possible glycemic control. Good control is essential to the prevention of vascular complications (Zhu et al., 1999). Moreover, strict long-term glycemic control reduces the incidence of complications associated with diabetes (Laakso and Kuusisto; 1996).

6. Strategies

The initial step in the management of every patients with glucose intolerance is to define the goals of metabolic control. These differ between patients depending on age, life expectancy, presence of co-morbid conditions or other illnesses, and the ability of patients to comply with the treatment program. Glycemic control can be achieved only when insulin secretion and insulin requirements are equal. Dietary advice, regular aerobic exercise and oral hypoglycemic agents are the strategies used to normalize hyperglycemia (Mahler and Adler, 1999; Zinker, 1999).

6.1. Dietary management of Diabetes

All clinicians recognize that dietary factors play a role in the treatment of diabetes. Three basic goals for diet are generally recommended in diabetes patients. (ADA, 1995; Lipkin, 1999).

6.1.1. The first is assisting in good blood sugar control, preventing both highs and lows.

6.1.2. A second goal is to keep blood fats (lipid) low to prevent cardiovascular disease, a major complication of diabetes.

6.1.3. A third goal is simply to provide an optimal diet for health and well-being.

6.2 Current pharmacological options for the management of type 2 diabetes

Current pharmacological options for the treatment of type 2 diabetes include oral anti-diabetic medications and insulin therapy. These agents reduce hyperglycemia through five main mechanisms (DeFronzo, 1999).

6.2.1. Insulin induces glucose metabolism and suppresses glucose production.

6.2.2. Sulfonylureas stimulate pancreatic secretion of insulin.

6.2.3. Biguanides inhibit hepatic glucose production and enhance peripheral glucose uptake.

6.2.4. Alpha-glucosidase inhibitors reduce glucose absorption.

6.2.5. Glitazones stimulate insulin action, reduce hepatic glucose output, and increase peripheral glucose uptake.

In reality, however, the disadvantages of drugs used in type 2 DM include hypoglycemia, which is the most common side effect, weight gain, drug allergy, and patients concerns. A large insulin doses are often required for optimal control, which usually involve multiple injections, the fleshy tumors (lipohypertrophy at injection sites) and high cost, with attendant compliance issues (Ruoff, 1993; Lebovitz, 1998). In addition, type 2 diabetes patients are usually older. Dietary management plays less of a role in older diabetic patients (Morly, 1998).

6.3. Exercise

Exercise can play an important role in the therapy of patients with diabetic (Blonk et al., 1994; Lehman and spinas, 1996). Particularly, emphasis on balance and stability, is an important component of the management and treatment of older diabetes patients. The regular exercise helps regulate carbohydrate metabolism. Increased activity may improve glycemic control (Peirce, 1999). In each individual, the prescription should reflect an effort to optimize the anticipated benefits and minimize the risks from exercise. Benefits may include cardiovascular risk reduction, improved strength and physical fitness, a better quality of life

(Glasgow et al., 1997) and enhanced a psychological sense of well-being (ADA, 1990; McArdle et al., 1996). Moreover, it should be paced on factors that result in permanent lifestyle change and encourage a lifetime of physical activity (ACSM, 1998).

The common exercise programs prescribed by physicians and educators are normally referred to aerobic endurance exercises such as brisk walking, jogging, swimming, rowing, aerobic dance and riding a stationary bicycle (Pate et al., 1995). However, one of the major obstacle of the patient's undertaking for an exercise program is compliance. Compliance to an exercise program will be the highest point which patients select a type of exercise they enjoy (Swift et al., 1995). Unfortunately, these endurance aerobic exercise usually required space, equipment costs, and inconvenient to activities. Especially, the injury risk is particularly evident in elderly persons who are overweight and unfit (Carroll et al., 1992).

An impressive contrasts, the principle advantage of Tai Chi Chaun (TCC), Chinese conditioning exercise is a low intensity, low cost, easy accessibility, and appropriateness for implementation in the community (Wolf et al., 1997). Many studies demonstrated that TCC could reduce tension, anxiety, and mood disturbance (Jin, 1992). In addition, it is beneficial to cardiorespiratory function (Lai, 1995; Lan et al., 1996; 1997), balance (Tse and Baily, 1992; Wolfson et al., 1993; Wolf et al., 1996), strength (Wolfson et al., 1996), and rehabilitation in coronary patients (Lan et al., 1999), rheumatoid arthritis patients (Kirstens et al, 1991). TCC consists of many fundamental postures having graceful movements. During the performance of TCC, deep breathing and mental concentration are required to achieve harmony between body and mind with the intensity suitable for the elderly (Lai et al., 1995; Lan, 1996). In Thailand, TCC becomes more and more popular among the elderly Thai and Chinese people.

For the best of our knowledge the effect of TCC on patient who has diabetes has not been completely evaluated. In this study, we apply TCC to verify the beneficial effect, if present, could be useful ultimately. It can confirm that TCC is one choice of appropriate exercise to recommendation for diabetic patients. Therefore, the objective of this study was to determine the effect of Chinese style aerobic endurance exercise "Tai Chi Chaun" on glycemic control and aerobic capacity in NIDDM (type 2 DM) patients.

CHAPTER II

LITERATURE REVIEW

Exercise and Diabetes mellitus

Exercise has been recommended to the diabetic individual as long as this disease has been known (Vranic and Berge, 1979). An exercise prescription needs to be tailored to each person's unique set of circumstances (Christakos and Fields, 1995). Exercise recommendations may differ widely based on the type of diabetes (type 1, type 2 or pre-diabetes), age-group or special characteristics of the patient (e.g., adolescent, female), and the presence or absence of chronic diabetic complications (Devlin and Ruderman, 1995; Zinker, 1999).

Benefits of Exercise in type 2 DM

A. Glycemic control

Hyperglycemia in type 2 DM is primary the result of insulin resistance and impaired insulin secretion. Many persons with type 2 diabetes are hyperinsulinemic patients (i.e., the one requiring the largest insulin production for glucose regulation). Hyperinsulinemic patients also respond best to exercise, which is consistent with the observation that exercise acts by reversing insulin resistance (i.e., exercise increases insulin sensitivity) (Holloszy, 1986; Wallberg-Henriksson, 1992). In accordance with Wasserman and co-worker (1995) the use of exercise as a therapeutic impact may be particularly beneficial because it has a positive impact on insulin resistant, the fundamental abnormality of this metabolic state.

Physical training results in lower fasting and postprandial insulin concentrations and increased insulin sensitivity. Especially, the improvement in insulin sensitivity resulting form regular physical exercise may be major importance in improving long-term glycemic control (Horton, 1994; Peirce, 1999). Increased insulin sensitivity is lost after as little as three days of inactivity (Lehmann and Spinas, 1996).

1. Short-Term Effects of Exercise

Exercise is characterized by an increase in glucose utilization and a seemingly paradoxical fall in circulating insulin level. Therefore, exercise must stimulate insulin-independent, glucose uptake, increase insulin action, or both. Studies conducted in vitro showed that muscular contraction can stimulate glucose uptake in the complete absence of insulin (Ploug et al., 1986).

Improvement in glycemic control and glucose tolerance associate with exercise in persons with type 2 diabetes. Regularly performed vigorous exercise can result in significant improvement in glucose tolerance within a relatively short time (fewer than 7 days) in some persons with type 2 diabetes (Schneider, 1986). The improvement in glucose tolerance appears to be caused by a decrease in insulin resistance, that is, to a greater susceptibility to the action of insulin. This can occur even without changes in body weight, body fat content, or VO_2max.

Devlin studied the effects of exercise until muscle fatigue compared with no exercise in persons with type 2 DM, and reported that on the mornings after exercise, endogenous glucose production rates were 20 per cent lower than on days with no exercise the preceding evening. Because increased endogenous glucose production that occurs overnight is believed to be a primary cause of fasting hyperglycemia in type 2 DM, a single bout of evening exercise can have clinical significance 12 to 16 hours later (Devlin, 1987).

The effect of a single exercise session in persons with type 2 DM is to lower blood glucose concentrations. The acute decrease in plasma glucose levels leading to improvements in glucose metabolism, possibly related to an increase in insulin sensitivity in muscles and other tissue that persists for several hours to days after the exercise (King, 1995; Larsen et al., 1997). This is related to (1) the need for replenishment of decreased muscle and liver glycogen stores and (2) increased glucose metabolism in muscle.

Braun and co-works (1995) compared the intensity of exercise 1) low-intensity (50 per cent VO_2max) (LO), 2) high-intensity (75 per cent VO_2max) (HI), and 3) no exercise. Insulin sensitivity (determined both by steady-state plasma glucose concentration and rate of glucose disposal per unit plasma insulin) were almost identical after LO or Hi. A value were significantly greater than after NX. They concluded that under these conditions Lo is as effective as HI in enhancing insulin sensitivity in people with type 2 DM.

Regarding to the rate of insulin-stimulated glucose disposal is reduced in individual with insulin resistance, and is associated with a blunted or absent increase in energy expenditure in response to a glucose load. Braun and co-worker (1996) reported that the energy expenditure appeared to be determined by the relative balance between energy required to store glucose and energy saved by suppression of glucose production. The decrease in plasma glucose in diabetic subjects was due to greater glucose utilization (Giacea et al, 1998).

Usui and co-workers (1998) studied the effect of low intensity bicycle exercise on the insulin-induced glucose uptake in obese patients with type 2 diabetes. They founded significantly enhance the lower level of insulin-induce glucose uptake shortly after exercise and might useful for the treatment of post-prandial hyperglycemia.

2. Training Effects of Exercise

The repletion of muscle glycogen after exercise has been proposed to occur in two phases (Garetto et al., 1986). In phase **one**, glucose uptake is elevated, glycogen synthase activity is also elevated, and muscle glycogen is rapidly restored. This phase occurs immediately after the cessation of exercise and is notable in that it does not requires insulin, In the **second** phase, muscle glycogen has returned to near-normal levels and glucose uptake require insulin. Phase two is characterized by a marked and persistent increase in insulin action. Price and his co-workers (1994) suggested that muscle glycogen synthesis is predominantly insulin-independent the first hour after the cessation of contraction, but it is insulin-dependent after this interval.

Long-term studies demonstrated a sustained improvement in glucose control for as long as regular exercise is maintained in most patients with type 2 DM. Vanninen and co-workers (1992) studies 78 patients in a largely unsupervised about 70 per cent aerobic exercise home-based program, 30-60 min per session, 4 times per week for 1 year. Improved glucose and insulin levels persisted for a full year and were associated with a decreased level of HbA1c. Changes were greatest in the patients reporting higher intensity exercise.

Schneider and co-workers studied (1992) 111 patients with type 2 DM given 60-75 per cent aerobic exercise, 40-60 min, 4 times per week for 3-4 months. They reported that levels of HbA1c continued to improve over a 3-month training period. Moreover, Raz and his colleagues (1994) confirmed that the improvement in metabolic control persisted significant reduction in patients who continued to exercise at varying level at home during 1 year of follow up.

Khan and Rupp (1995) determined the effect of 15 week individualized exercise in 39 sedentary type 2 DM, on an oral hypoglycemic drug and no specified diet regimen. Sixty-two per cent of this group showed a reduction in HbA1c values.

Mourier and co-workers (1997) reported that the effect of intense physical training program (45 minute cycling at 75 per cent of oxygen uptake peak, two time per week and an intermittent exercise one time per week for 2 month) on abdominal fat distribution, glycemic control, insulin sensitivity in subjects with type 2 diabetes. The results showed that physical training resulted in improvement in insulin sensitivity with concomitant loss of visceral adipose tissue, but did not significantly affect body weight. The change in visceral abdominal fat was significantly associated with the improvement in insulin sensitivity and increased their VO_2 peak. After that, Dunston and co-workers (1997) confirmed that concomitant program of moderate exercise can prevent the deterioration in glycemic control of subject with type 2 diabetes.

Aerobic endurance exercise has traditionally been advocated in the treatment of type 2 diabetes. However, Eriksson and his co-workers (1997) determined the effect of circuit resistance training (moderate intensity, high-volum, twice a week). The result showed that there was a significant improvement in on long term glycemic control (HbA1c), muscle endurance, and the cross-sectional area of muscle increased by 21 per cent. Later, Ishill and his colleagues (1998) showed that moderate intensity, high volume resistance training five time a week can improve insulin sensitivity in nonobese type 2 diabetes patients without altering VO_2max.

B. Weight loss

The majority of type 2 DM patients are overweight. Weight loss is an important component of treatment. Exercise may affect weight loss in several different way. **Firstly**, exercise increases calorie expenditure during the exercise bout. **Secondly**, it may offset the effect of calorie restriction on energy expenditure. The combination of diet plus exercise has been shown to improve weight loss compare with diet alone (Wing et al., 1989).

Kriska and co-worker (1994) elucidated weight loss and the accompanying reduction in body fat and its distribution enhance glucose tolerance and insulin sensitivity. Exercise may also promote dietary adherence and may improve mood and self-esteem, leading to more control over dietary intake modification (Blonk et al., 1994). Braun and co-workers (1996) suggested that the most successful approach to long-term weight control involves the combination of diet, exercise, and behavior.

C. Cardiovascular risk factor

The reduction in the risk of myocardial infarction with the maintenance of an active, compared with a sedentary lifestyle is estimated to 35-55 per cent (Manson et al., 1995). Reducing the risk of cardiovascular disease in healthy individuals patients with type 2 diabetes by regularly performed exercise is supported by several studies (Raz et al, 1994; Eriksson and Lindgarde, 1998).).

Moreover, Estacio and co-workers (1996) suggested that weight loss, smoking cessation, and aggressive blood pressure control would appear to be important in improving exercise capacity and potentially improving the increased cardiovascular mortality associated with an impaired exercise capacity .

D. Psychologic benefits

Regular exercise is an effective nonpharmacologic therapy for stress, sleep disorder, depression, and anxiety, as well as such chronic conditions of aging as hypertension, obesity,diabetes mellitus, coronary artery disease, hyperlipidemia, and constipation (Kligman and Pepin, 1992). Moreover, it improved mood, self-esteem, increased sense of well-being, an enhanced quality of life (ADA, 1990), improved concept of personal control and self-efficacy (ACSM, 1998).

E. Cardiorespiratory fitness

Cardiorespiratory fitness can be measured by maximum oxygen uptake (VO_2max), lactate threshold (LT) or ventilatory threshold (VeT), flexibility, muscular strength and endurance, and body composition (Wasserman et al., 1994; McArdle et al., 1996). Many conditions, such as aging, obese and cardiovascular disease, hypertension, diabetes mellitus, result in the deterioration of cardiorespiratory fitness (Estacio et al., 1996). Katoh and co-workers (1996) suggested that type 2 DM patients were significantly lower in maximum oxygen uptake per unit body weight, maximum load compared with health volunteers. Low cardiorespiratory fitness was associated with increased risk for type 2 diabetes (Wei et al., 1999).

Persons with type 2 DM have a decreased exercise performance compared with nondiabetic subjects. Regenteiner and co-wokers (1995) suggested that reduced rate of increase in oxygen consumption during increasing submaximal work loads in type 2 DM due to limitations in oxygen delivery may impair exercise performance. Dorin and co-workers (1996) confirmed that insulin resistant in type 2 DM patient would limit transport of extracellular glucose to skeletal muscle during exercise, resulting in impaired exercise performance. Nyholm et al explored the mechanism behind condition in insulin-resistant first-degree relatives of type 2 diabetes patients and founded that this condition characterized by an increased number of type IIb muscle fibers which, reflected a reduced physical activity level and fitness (Nyholm et al., 1997).

Regensteiner and co-workers (1998) studied the change in the rate of VO_2 in response to the onset of constant-load exercise measured by VO_2 uptake kinetics and slowed VO_2 uptake in type 2 diabetes compared with healthy control. There were slower VO_2 and heart rate kinetic than did controls at constant workload below lactate threshold. The findings may reflect impaired cardiac responses to exercise, although an additional defect in skeletal muscle oxygen diffusion or mitochondria oxygen utilization is also possible.

Regular exercise involves in cardiovascular fitness. This means that it can prolong exercise duration, delay or reduce the onset of fatigue during exercise, and stimulate recovery time (Wallberg et al., 1998). Thus, exercise is recommended to improve these variables. This result is consistent to the study of exercise and type 2 diabetic patients, the result showed that VO_2max was higher in the training group than control group (Poirier et al, 1996; Ligtenberg et al, 1997) or improved aerobic fitness (Dunston et al., 1997).

For individuals with diabetes, exercise has both benefits and risk. Today with more research available, guidelines was perpared to assist persons with diabetes to exercise safety. Because of the high incidence of ischemic heart disease in type 2 DM, the goal is to assure that the benefit of exercise outweigh the risk. Older obese type 2 DM patients can achieve significant metabolic benefit under low-intensity-programs (40-50 per cent of maximal oxygen consumption) as effective as high-intensity (75 per cent of maximal oxygen consumption) (Fujii, 1994; Braun et al., 1995; Colberg et al., 1996). The recommended frequency and duration of exercise is three times per week or every other day and, as adjunct for weight reduction, five to seven times per week for 30 to 45 minute (Raz et al., 1994; Lehmann and Spinas, 1996).

An aerobic activities that require running and jumping are considered high impact type of exercise. Generally, these activities are associated with a higher incidence of musculoskeletal injuries in the beginning as well as long-term exercise than low impact and nonweight bearing type activities (Pollck et al., 1991; Carrol et al., 1992).

In addition, the patient must be educated with regard to proper footwear and daily foot inspection. Fluid intake is of great importance when exercising for prolonged period or in warm and humid environment. With the proper motivation and medical supervision, people with type 2 diabetes can enjoy regular physical exercise as a means of enhancing metabolic control and improving physical fitness (Wallberg et al., 1998).

Adherence to programs of physical training over the long term have been remarkably variable. Long term compliance will most likely be achieved when the intervention is both attainable and attractive (Oldridge et al., 1995). Moreover, physicians or health educator can enhance the rate of compliance by clearly defining the expected health benefits of exercise for the individual patient, such as a decrease in serum glucose or blood pressure. An effective exercise prescription is more likely to be followed if recommended activities fit into the patient's daily schedule and lifestyle. Limitations, such as lack of transportation to an exercise class or required wide area, expensive and technically sophisticated equipment and unavailability of an exercise partner, need to be considered.

Patients should be encouraged to exercise regularly, increase their pace gradually, and vary their activity to maximize both compliance and enjoyment, Recommending a particular community-based exercise program (e.g. through a parks and recreation department center) is encouraged. Simple modifications of routine daily activities can be instrumental in reaching fitness goals. The importance factor is to design a program for the individual to provide the proper amount of physical activity to attain maximal benefit at the lowest risk (Kligman, 1992; Benjamin, 1995; ACSM, 1998).

Tai Chi Chaun (TCC) is a Chinese traditional conditioning exercise. It was similar to moderate physical exercise and suitable for the elderly. TCC, mean "Supreme Ultimate Fist". It was practiced in China since the ancient time. TCC is gaining wide popularity in the West for its beneficial effects on physical and mental well-being. "Chaun" (fist) means much more than a clenched hand. To a Chinese person, it means "studies and training associated with a material art". However, Tai Chi, as it is generally called, is frequently used for improving and maintaining health (Crompton and Alberight, 1996).

TCC was devised by Chan San Feng for meditation and self-defense in the thirteenth century A.D. (Koh, 1981). In those early days, the art was simply a powerful, combative mode of exercise and fighting. Slowly, TCC developed a purely health and exercise aspect. During the 1950s, leading Chinese Tai Chi experts met and produced a number of Tai Chi Forms or movement sequences. These were graded in terms of degree of difficulty and length. Since then, these Forms have been gaining in popularity (Crompton and Alberight, 1996).

The Form presented in this study is the 18 step or Simplified. It is the most widely taught and practice at early morning in many parks of Bangkok and other provinces. Each posture has a name, such as " White Crane Spreads Its Wings." Relax and breathe naturally when perform TCC and imagine that you are in a pleasant rural setting with fresh air and the scent of flowers or pine trees. As you lift your arms, the beauty and energy of Nature floods into your arms and upper body. As you lower your arms, this energy flows down into your lower body, legs, and feet. Do this exercise without forcing, Imagine that a gentle breeze flows into and through you, eliminating unquiet thoughts.

Beneficial effects of TCC training.

A. Cardiorespiratory

Many studies evaluated the training effects of TCC on 2-year trends of cardiorespiratory function in older individuals. The data substantiated that practicing TCC regularly may delay the decline of cardiorespiratory function in comparison with sedentary control group. In addition, TCC may be prescribed as suitable aerobic exercise for older adults (Schnieder and Leung, 1991; Lai et al., 1995).

Lai and co-workers (1993) founded that, at the maximal exercise level and at the ventilatory threshold, the TCC group also showed significantly higher VO2, O2pulse, and WR than the respective values of the control group. This result imply that TCC training may be beneficial to the cardiorespiratory function of older individual.

Lan and co-workers (1996) compared the health-related fitness between geriatric TCC practitioners with sedentary counterparts. TCC group showed higher peak oxygen uptake in peak exercise and greater flexibility and lower percentage of body fat in comparison with sedentary counterparts. It may be prescribed as a suitable conditioning exercise for the elderly.

Lan and co-workers (1997) investigated the gains of health fitness in TCC participants 12-month training. They founded that the TCC group showed increase in maximal oxygen uptake, thoracic/lumbar flexibility, muscle strength of knee extensor, and knee flexor. The control group showed no significant change in these variables. They indicated that 12-mouth TCC program is effective for improving health fitness of the elderly.

B. Balance and reduce falls

Tse and Baily (1992) investigated the potential value of Tai Chi in promoting postural control of the well elderly and showed that the Tai Chi practitioners had significantly better postural control than the sedentary non-practitioners. Province and co-workers (1995) suggested that treatment including exercise for elderly adults such as TCC reduce the risk of fall.

Wolf et al (1996), evaluated the effects of two exercise approaches, TCC and computerized balance training (BT), on specified primary outcomes (biomedical, functional, and psychosocial indicators of frailty) and secondary outcomes (occurrence of falls) in older subjects living in the community. Intervention length was 15 weeks. They founded that fear of falling responses and intrusiveness responses were reduced after the TCC intervention and reduce the risk of multiple falls after adjusting for fall risk factors. TCC warrants further study as a exercise treatment to improve the health of older people.

C. Mood and Anxiety States

Jin assessed psychological and physiological function following participation in Tai Chi. Relative to baseline levels, subjects reported less tension, depression, anger, fatigue, confusion and state-anxiety. They felt more vigorous (Jin, 1989).

Later, Jin examined efficacy in post stressor recovery by 4 treatment group (Tai Chi, brisk walking, meditation, and neutral reading). All 4 treatment, in general, were equally effective in reducing mood disturbance caused by mental/emotional stressors. It is relaxation therapy for chronically illness and promoted emotional well-being (Jin, 1992).

D. Rehabilitation

Kirsteins and co-workers (1991) evaluated the safety and potential use of a weight-bearing exercise, Tai Chi Chaun, for rheumatoid arthritis (RA) patients. The data showed that, no significant exacerbation of joint symptoms. Thus, TCC exercise appears to be safe for RA patients and may serve as an alternative for their exercise therapy and part of their rehabilitation program.

Recently, TCC has been prescribed as cardiac rehabilitation in medical centers. Lan and co-worker (1999) assessed the training effect of a 1-year TCC program for low-risk patients with coronary artery bypass surgery (CABS) after a postoperative outpatient (phase II) cardiac rehabilitation program. The TCC group increased in VO2peak and increased in peak work rate. This study demonstrated that a 1-year TCC program for low-risk patients with CABS could favorably enhance cardiorespiratory function.

CHAPTER III

MATERIALS AND METHODS

A. Materials and Equipment

1. A weighing scale (Yamato DP-6100GP)
2. A scale for height
3. A wet Spirometer
4. A scale for flexibility (Will sit and reach)
5. Bioelectrical impedance machine (A hand-held model Bodystat-1500, Bodystat Ltd, Isle of Man, UK)
6. Cardiotachmeter (Polar Sport Tester; Polar Electro Oy FIN-90440, Finland)
7. Oxygen and carbon dioxide gas analyzer (Quinton Metabolic Cart, QMC)
8. Cardiac stress testing equipment (Quinton instrumen CO, Q 4500)
9. Treadmill (Quinton instrumen CO, Q55 series 90)
10. A noninvasive blood pressure monitor (Quinton instrumen CO, model 412)
11. Glucose self-monitoring (A hand-held model Precision Q.I.D)
12. An automated analyzer (COBAS MIRA S, F. Hoffman La Roche Ltd. Co Diagnostica, Basel, Switzerland)

B. Methods

1. Subjects

Sixteen patients with type 2 DM (5 men, 11 woman) aged 52-69 years were recruited through announced and advertised at diabetic clinic, King Chulalongkorn memorial hospital, volunteered to serve as subjects in this study.

1.1. Inclusion Criteria

1.1.1. Type 2 diabetic patients, male and female, age 55-70 yr.

1.1.2. Sedentary life style

1.1.3. No engage in any regular exercise training at least 1 year

1.1.4. Currently treated with oral hypoglycemic agents, insulin or combinations

1.1.5. Stable with good to fair degree of diabetic control (HbA1c was less than 8 percent)

1.1.6. No severe diabetic complications e.g. nephropathy, retinopathy

1.1.7. No pulmonary or musculoskeletol disease or any orthopedic limitations to exercise testing and training

1.1.8. No psychological disorder

1.1.9. Informed consent

1.2. Exclusion Criteria

1.2.1. History of frequent hypoglycemic episodes (more than 4 times per month)

1.2.2. Presence of active or severe ischemic heart disease e.g. unstable angina, recent myocardial infarction

1.3. Concomitant Medications

1.3.1. Permitted medications: Oral hypoglycemic agents sulphonylureas, biguanides, alpha glucosidase inhibitors, angiotensin converting enzyme inhibitors, calcium channel blockers, aspirin, isosorbide dinitrate

1.3.2. Prohibited medications: Beta -blocker

1.4. Entry to the study:

Owing to safety considerations, the study protocol will be reviewed and permitted by board of institutional ethical committee. Subjects completed a history and physical examination as well as electrocardiogram, laboratory investigations. The medical data will be carefully evaluated by physician.

Prior to informed consent form, subjects will give a full explanation of the study, which contains purpose of study, expected benefits and potential risks, availability and details of alternative therapy for the disease. An assurance that the quality of medical treatment will not be affected if consent is not given, freedom to withdraw at anytime for any reason, and other requirements necessary for protection of the patient's human rights. (All aspects of the research study were in keeping with the principles embodied in the Declaration of Helsinki for experiments involving human subjects).

2. Study designs

A 16 weeks TCC exercise program was designed for the experimental group, and attendance recorded.

The examinations were arranged upon the first week, eighteenth week, and termination of sixteenth week. It consist:

2.1. Body weight and height

Height (cm) was measured to the nearest 0.5 centimeter on a standardized wall-mounted height board under the following conditions: without shoes; heels together; heels, buttocks, shoulders, and head touching the vertical wall surface, and with line of sight alight horizontally.

Body weight (kg) was measured to the nearest 0.02 kilogram on a digital platform scale (Yamato DP-6100GP).

2.2. Percentage of body fat

It was performed with bioelectrical impedance machine (Bodystat-1500) which is programmed to run on the manufacturer's prediction equation. The exact prediction equations used were not disclosed by manufacturer (Bodystat Ltd, Isle of Man, UK).

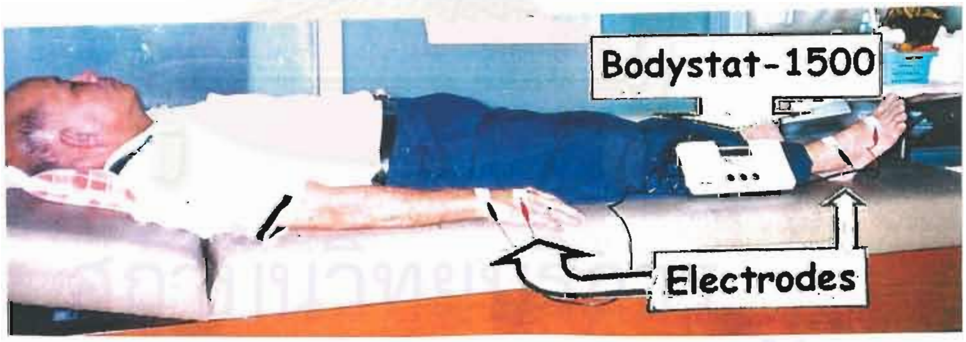


Figure 3.1 Photograph of percent body fat measurement by bioelectrical impedance (Bodystat-1500)

Subjects lied in a supine position on a nonconductive bed with arms and legs slightly abducted from the middle line of the body to ensure that no parts of the body were in contact with each other. Shoes and socks were removed, and each electrode site was prepared by swabbing with alcohol and then allowing the site to dry before electrode replacement. Two adhesive aluminum foil signal-introducing electrodes were placed at the middle of the dorsal surface and between styloid processes of radius and ulna of the hand. Each of two adhesive aluminum foil were placed at the third metacarpal and metatarsal phalangeal joint of foot and between the medial and lateral malleoli of the ankle, respectively. A low-level electrical current (typically 800 μA at a frequency of 50 kHz) was applied to distal electrodes and voltage drop was detect by proximal electrodes.

2.3. Vital capacity

The total volume of air that can be voluntarily moved in one breathe, from full inspiration to maximum expiration.

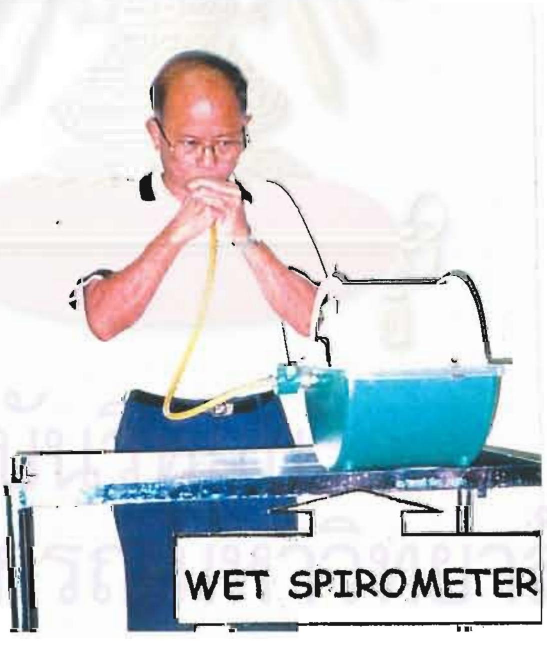


Figure 3.2 Photograph of vital capacity testing by wet spirometer

The vital capacity tests were performed with a wet spirometer and each subject was studied in the standing position. The subject rebreathes through a wet spirometer three times and an average of the three times was obtained these measurements (Figure 3.2).

2.4. Flexibility

Decades of inactivity can yield an astonishing degree of motor limitation imposed by lack of flexibility. Flexibility was recorded by a will sit and reach test to measure the flexion of thoracic/lumbar spine. Subjects, sit with hamstring stretch. No bending the knee, then leaning the upper body forward and stretching the arm to move box scale, forward flexed the trunk three times, and an average of the three times was obtained (Figure 3.3).

Figure 3.3 Photograph of flexibility testing by a will sit and reach test

2.5. Blood analysis

On the first, eighteenth and sixteenth of week, subjects upon referral were given instructions for a 12-hour fast after which time blood samples were drawn for analysis of fasting plasma glucose, glycosylated hemoglobin, serum cholesterol, HDL-cholesterol, triglyceride by enzymatic method (Automated analyzer).

C. Tai chi Chaun training

The TCC program was held in garden of terrace thirteenth floor at OPD building, King chulalongkorn memorial hospital. Subjects (16 persons) and other member who interesting in TCC exercise (10-15 persons) practiced TCC in the early morning for about 1-hour on Monday, Wednesday, and Friday and at home or park near their house on some Saturday or Sunday. Physician and observer monitored subjects' health and training condition closely through 16 weeks. During the performance of TCC, they were led by a Tai Chi Chaun master and imitated the motions and postures with the same speed. In addition, subjects perform each posture according to a prerecorded form sequence on VDO tape to ensure the same time course (Figure 3.4).

Figure 3.4 Photograph of subjects during performed TCC exercise

Each session was divided as following:

1. 10 minute of warm-up (lower back and hamstring stretching, gentle calisthenics, and balance training).

2. 40 minute of practicing TCC, which separated 3 set, each set included, 18 postures.
3. 5 minute of cool-down.

Monitoring of capillary blood glucose was done following each session of TCC exercise in every subject by a glucometer (*Precision QID*, an Abbott Laboratory, USA)

The exercise intensity of TCC was measured in subjects after 2 months of training. During the performance of TCC, heart rates were monitored by a cardiotachmeter (Polar Accurex Plus monitor) which consisted of an electrode-belt transmitter around the chest and wrist microcomputer receiver throughout the exercise. Heart rates were recorded in each 1-minute interval. The exercise intensity was calculated as a percentage of the maximum heart rate.

D. Exercise test protocol

The exercise test was on the first, eighteenth, and sixteenth week at 107 laboratory exercise room of Physiology department, Faculty of Medicine, Chulalongkorn University.

It was conducted on sooner than 2 hour after breakfast. Medication treatment was not stopped on the day of the test. Cigarette smoking and consumption of caffeinated beverages were forbidden in the morning of the test. Resting was enough at last night.

The procedures were fully explained before the test. The body weight, height, lung capacity, flexibility and percentage of body fat were recorded before the test, respectively. Blood glucose was monitored before and after testing. Afterward, the resting heart rate and blood pressure were recorded after sitting quietly for 5 minute. Each subject performed a grade exercise test on a mechanically braked, O_2 and CO_2 gas analyzer (QMC) and treadmill ergometry that was calibrated routine according to the directions of the manufacturer (Quinton Instruments, Seattle, Wash., USA). A clamp is placed on the nose and the patient breaths through a mouthpiece attached to a nonrebreathing valve.

During exercise test subjects were allowed to loosely hold on handrails for equilibrium and prevent to falls. The maximum treadmill protocol was initiated with 2-minute warm-up at speed 60 meters per minute and 0 % grade. The speed and the grade were then increased to 66 meters per minute and 2.5 % grade respectively. The slope was increased by 2.5 % each minute thereafter. When a 10 % grade was reached, the speed was set at 84 meters per minute, increasing the slope by 2.5 % each minute (as shown in Table 3.1) and the test was conducted until intolerable dyspnea or exhaustion or muscle fatigues. Subjects were verbally encouraged throughout the test. At the end of the test, the subjects walked for 2 minute at 0% grade and at 60 meters/minute to properly warm-down.

<u>The criteria for stopping the test were if</u>

1. The subject signaled he/she could no longer continue, and treadmill was then slowed and grade reduced, or
2. The subject grasped the handrails to keep up with the moving belt or straddled the belt.

During the exercise, an electrocardiographic lead (standard limb lead) and blood pressure was continuously monitored for early evidence of any myocardial ischemic changes or cardiac arrhythmia.

Table 3.1 Graded maximal exercise test protocols for type 2 diabetic patient subjects adopted in the study. Speed in meter per minute, grade in % elevation, and time in minutes (De Vito, 1997).

Stage	Speed	Grade	Time
1	60	0	2
2	66	2.5	1
3	66	5	1
4	66	7.5	1
5	66	10	1
6	84	10	1
7	84	12.5	1
8	84	15	1
9	84	17.5	1
10	84	20	1

E. Equipment and measurement

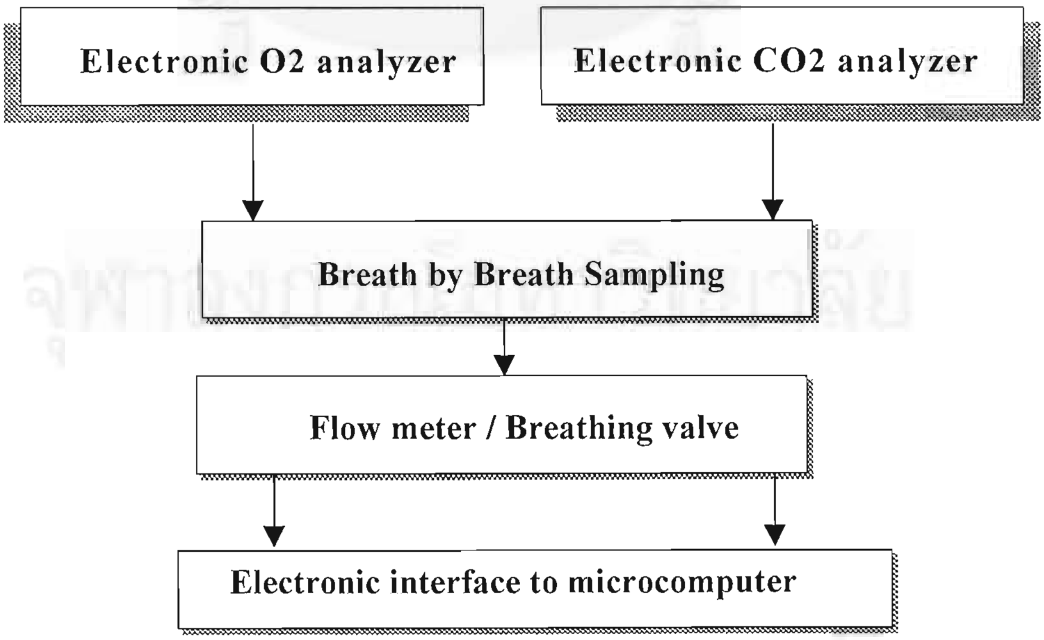
The quantity of energy generated by the body during rest and physical activity can be accurately determined using several different methods. These methods are broadly classified as direct and indirect calorimetry. This study used indirect calorimetry method by computerized instrumentation to measure oxygen uptake during physical activity.

In prior to, advances in computer and microprocessor technology enable exercise scientists to efficiently measure metabolic and physiologic responses to exercise. A computer is interfaced with at least three instruments: a system to continually sample the subjects 's expired air, a flow meter or turbine device to record the volume of air breathed, and oxygen and carbon dioxide analyzers to measure the fractional composition of the expired gas mixture.

The computer is programmed to perform the metabolic calculations based of the electronic signals it receives from the instruments. More advance systems include automated blood pressure, heart rate, and temperature monitors as well as computerized programs to regulate the speed, duration, and workload of a treadmill.

The expired air was measured and analyzed breath-by-breath by a computerized system. Gas analyzers were recalibrate before each test to correct for drift in the analyzers. The exercise test was conducted in an air condition laboratory with atmosphere temperature of 22-26°C, barometric pressure of 756-772 Torr, and relative humidity of 50-70 %.

Figure 3.5 Computer systems approach to the collection and analysis of physiologic and metabolic data.



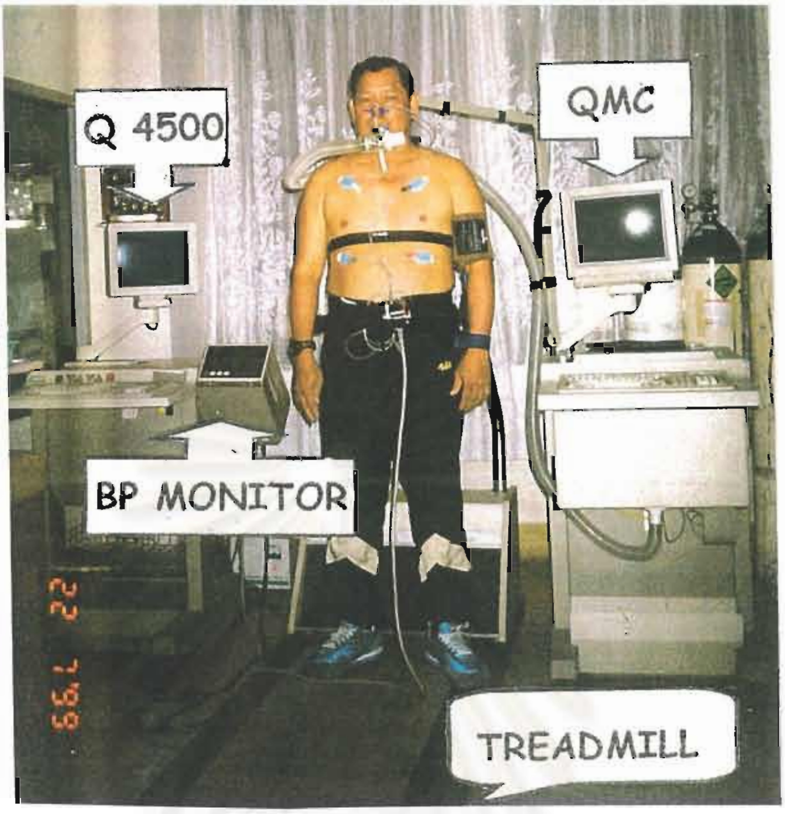


Figure 3.6 Photograph illustrated of preparing subject and exercise test machine.

Exercise and cardiorespiratory parameters included heart rate (HR), oxygen uptake (VO_2), carbon dioxide production (VCO_2), oxygen pulse, minute ventilation (V_E), tidal volume (V_T), respiratory exchange ratio (R), ventilatory equivalent for O_2 (V_E /VO_2), ventilatory equivalent for CO_2 (V_E /VCO_2, end tidal PO_2 ($P_{ET}O_2$), end tidal PCO_2 (P_{ET} CO_2), and work rate (WR) were measured during the test. The data were averaged every minute for further analysis.

The VO_2 max was defined as the peak-attained oxygen uptake by the following criteria (Wasserman et al., 1994; Poole and Richardson, 1997):

1) The increase of VO_2 was less than 2 ml/kg/min in the last 2

minutes (or constant VO2 despite increment increase).

2) Maximal heart rate (HRmax) near theoretical HRmax ±10 beat (HRmax = 220 - age).

3) Respiratory exchange ratio exceeded 1.10.

The ventilatory threshold (VeT) was determined by at least two of the following criteria (Wasserman et al., 1994; Davis et al., 1997):

1) The V_E /VO_2 began to increase systematically without a corresponding increase in the V_E /VCO_2.

2) The $P_{ET}O_2$ began to increase without a decrease in the $P_{ET}CO_2$.

3) Departure from linearity for minute ventilation.

F. Data analysis

Paired Student's "t-test" was used to evaluate difference between pre-training and post-training physiological variables of TCC. A *p*-value less than 0.05 was considered statistically significant. All data are presented as mean ± SD.

CHAPTER IV

RESULTS

A total of 16 subjects were enrolled and all complete the study. But one subject refused to perform cardiorespiratory fitness test. The ranging in age of subject from 52 to 69 year (mean 58.81± 5 years) and 147 to 177 centimeters (mean 157.34± 8 centimeter) in body height.

Body weight, percentage of body fat, flexibility, vital capacity, resting heart rate, fasting plasma glucose, glycosylated hemoglobin, lipid profile, and cardiorespiratory fitness were determined at baseline, in the middle (2 months), and at the end (4 months).

A. Effect of TCC on exercise intensity

The exercise intensity was determined in all TCC subjects. During the performance of TCC training, the mean heart rate (HR) of subjects steadily increase in the first 10 min. Then, it achieved a steady state toward the end of exercise. During the steady-state performance, the mean HR was 102.0 ± 2.16 beat/min (Figure 4.1). In comparison with the HRpeak attained from the exercise test, important finding is discerned, mean HR during the steady-state performance approximated 70 per cent of HRpeak. The results demonstrated that the exercise intensity of TCC training is moderate and aerobic in nature.

B. Effect of TCC on Physical Characteristic

The physical characteristic data are shown in Table 4.1. There are no significant differences in body weight, percentage of body fat, vital capacity, and heart rate between pre training and post training. However, the flexibility showed significantly increase from 3.69 ± 8.57 to 4.94 ± 8.63 centimeter in baseline to first follow up (2 months) and 3.69 ± 8.57 to 5.91 ± 8.78 centimeter in comparison between baseline and at the end of training (16 months) ($p<0.05$).

C. Effect of TCC on Blood Biochemistries

As showed in Table 4.2, There were statistically significant decreased 15.06 per cent in fasting plasma glucose concentration (FPG) from 156.88± 43.03 to 133.25± 22.26 mg/dl ($p< 0.05$) and 13.46 per cent in glycosylated hemoglobin (HbA1c) concentration from 6.91± 0.82 to 5.98± 0.34 % ($p< 0.01$) in comparison between the beginning and the end of the study in TCC subjects. There was slightly decrease in cholesterol, triglyceride and Chol/HDL level but the change did not reach statistical significance in all of them. In addition, high density lipoprotein (HDL) and low density lipoprotein (LDL) concentrations were unchanged after 16 weeks of TCC training.

D. Effect of TCC on Cardiorespiratory Fitness

Table 4.3 presents the change of variable obtained by the TCC training groups. After 16 weeks of training, the TCC group showed significant improvement in cardiorespiratory fitness.

1. <u>At the maximum exercise</u>, the TCC group showed significant increase ($p<0.05$) in VO_2peak (ml/kg/min), WRpeak (Watt) after 16 week of TCC training.

The TCC group showed a 10.68 per cent significant increase in VO_2peak from 20.03 ± 3.85 to 22.17 ± 4.23 ml/kg/min ($p < 0.05$) and 12 per cent increase in WRpeak from 107.5 ± 39.55 to 120.8 ± 45.91 watt ($p < 0.05$) after 8 weeks, and 30 per cent from 107.5 ± 39.55 to 140.2 ± 46.79 watt after 16 weeks of TCC training.

2. At the ventilatory threshold, TCC group also showed significantly increase in VO_2 ($p < 0.05$) and Work Rate ($p < 0.05$) after 16 weeks compared with baseline, 12 per cent (from 15.3± 3.67 to 17.21 ml/kg/min) and 55 per cent (from 51.8± 44.94 to 80.27 watt), respectively.

Table 4.1 The characteristics data of the subjects (n = 16)

	Baseline	1st Follow-up (After 8 week)	2 nd Follow-up (After 16 week)
Body weight (kg)	67.49 ± 10.63	67.38 ± 10.44	67.18 ± 10.44
Percentage of body fat (%)	36.17 ± 8.14	35.98 ± 8.32	36.0 ± 8.47
Flexibility (cm)	3.69 ± 8.57	4.94 ± 8.63*	5.91 ± 8.78**
Vital capacity (ml)	1909.37 ± 703.86	1910.0 ± 694.07	1984.37 ± 652.87
Heart rate (beats/min)	85.0 ± 8.6	84.50 ± 9.02	82.0 ± 7.62

* $p<0.05$, Significant differences from baseline to first follow-up

** $p<0.05$, Significant differences from baseline to second follow-up

Value are listed as mean ± SD

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Table 4.2 Change of biochemistris before and after in TCC training of type 2 DM subjects (n = 16).

	Baseline	1st Follow-up (8 week)	2 nd Follow-up (16 week)
Fasting plasma glucose (FPG, mg/dl)	156.88 ± 43.03	150.75 ± 19.93	133.25 ± 22.26*
Glycosylated hemoglobin (HbA_1C, %)	6.96 ± 0.83	6.73 ± 0.72	5.99 ± 0.34**
Cholesterol (Chol, mg/dl)	231.06 ± 39.61	238.0 ± 47.05	228.81 ± 32.64
Triglyceride (TG, mg/dl)	117.0 ± 50.62	104.75 ± 35.43	95.06 ± 45.20
High density lipoprotein (HDL, mg/dl)	54.45 ± 9.37	55.73 ± 8.81	54.71 ± 8.77
Low density lipoprotein (LDL, mg/dl)	153.21 ± 41.22	161.31 ± 49.80	155.08 ± 36.40
Chol/HDL	4.37 ± 1.11	4.38± 1.19	4.28 ± 0.97

* $p < 0.05$, ** $p < 0.01$, within group differences from baseline to follow-up
Values are listed as mean ± SD

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Table 4.3 Data of the cardiorespiratory fitness test (n = 15)

Cardiorespiratory fitness	Baseline	1st Follow-up (After 8 week)	2 nd Follow-up (After 16 week)
Peak exercise			
VO2 peak (ml / kg/m)	20.03 ± 3.85	20.63 ± 3.66	22.17 ± 4.23**
HR peak (beat/min)	141.87 ±13.12	144.13 ± 20.02	146.6 ± 20.04
WR peak (watt)	107.50 ± 39.55	120.8 ± 45.91*	140.2 ± 46.79**
Ventilatory threshold			
VO2 (ml/kg/min)	15.3 ± 3.67	16.49 ± 4.37	17.21 ± 3.97**
WR (watt)	51.8 ± 44.95	65.0 ± 44.06	80.27 ± 41.58**

* $P<0.05$, Significant differences from baseline to first follow-up

** $P<0.05$, Significant differences from baseline to second follow-up

Value are listed as mean ± SD

41

41

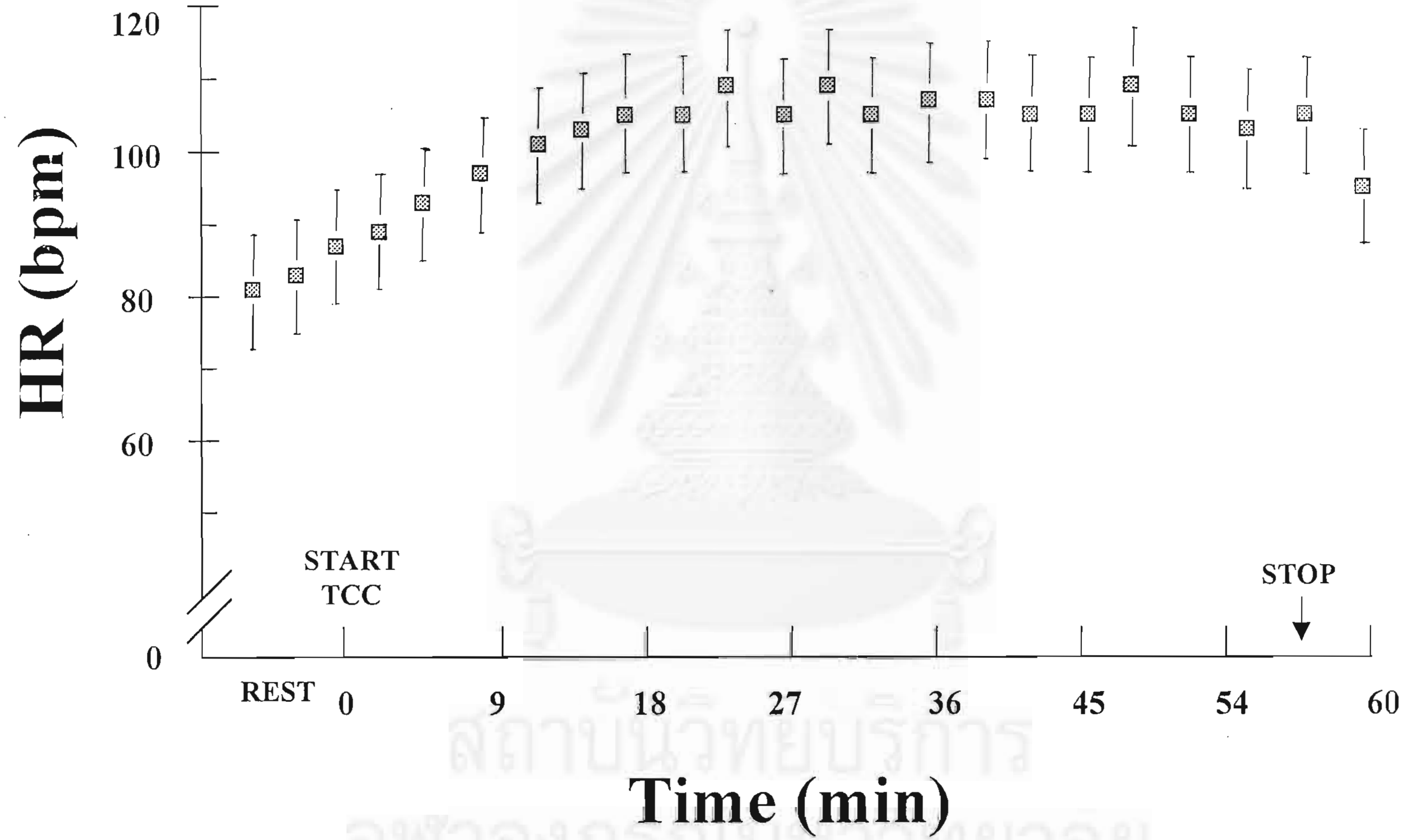
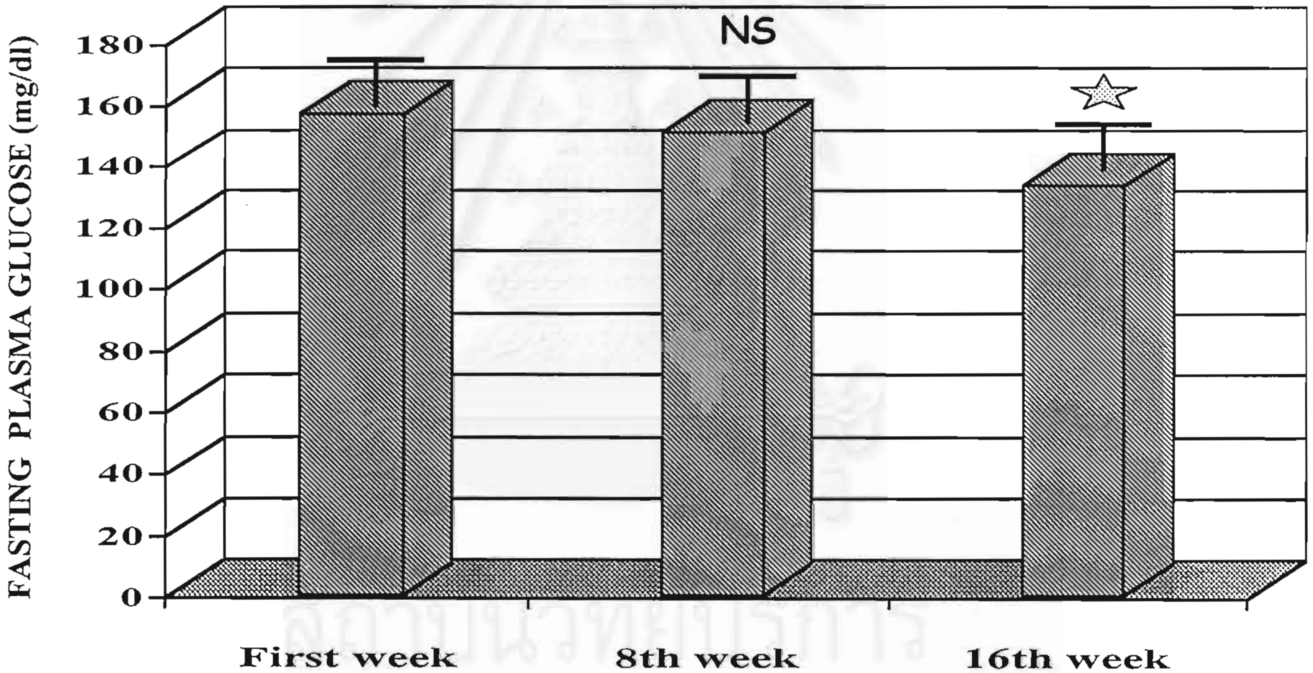


Figure 4.1. The heart rate response of subjects during performance of TCC (values are mean + SD). Subjects' mean HR increased steadily during the first 10 minutes, then achieved a nearly steady state to the end of the exercise.

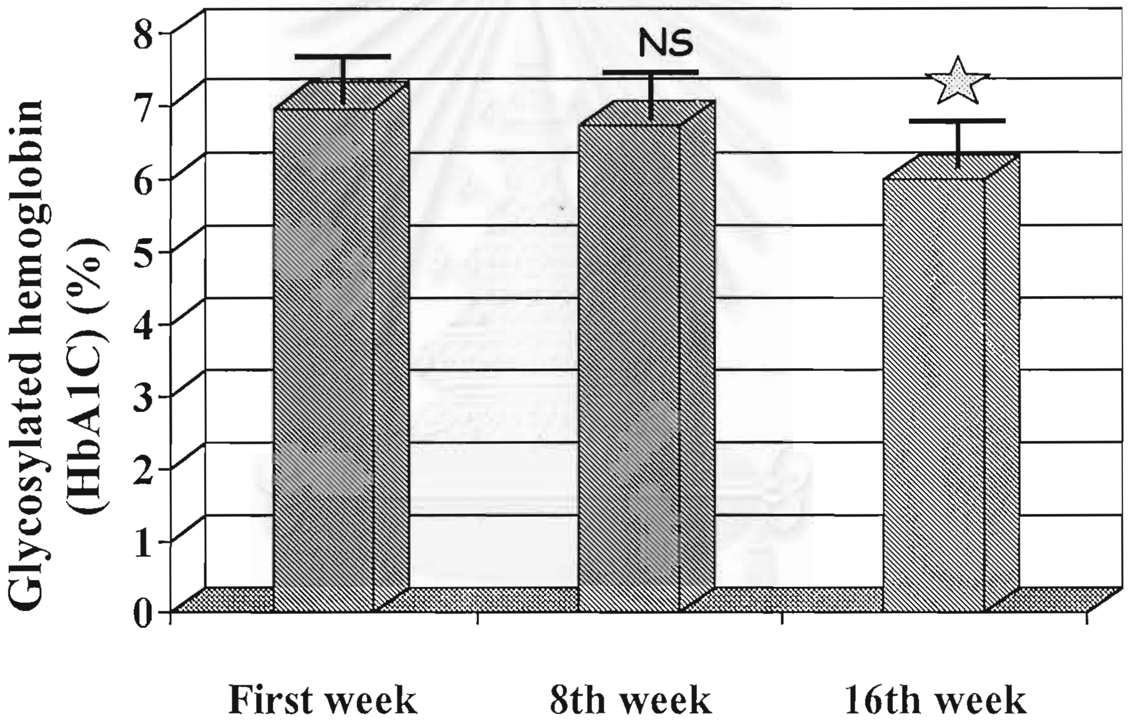
Figure 4.2 Means and SD of Fasting plasma glucose (FPG) of type 2 DM before and after 8 weeks, 16 weeks TCC training.



☆ Significant difference as compare to baseline measurement

NS No significant difference as compare to baseline measurement

Figure 4.3 Means and SD of glycosylate haemoglobin (HbA1c) of type 2 DM subjects before and after 8 weeks, and 16 weeks TCC training.

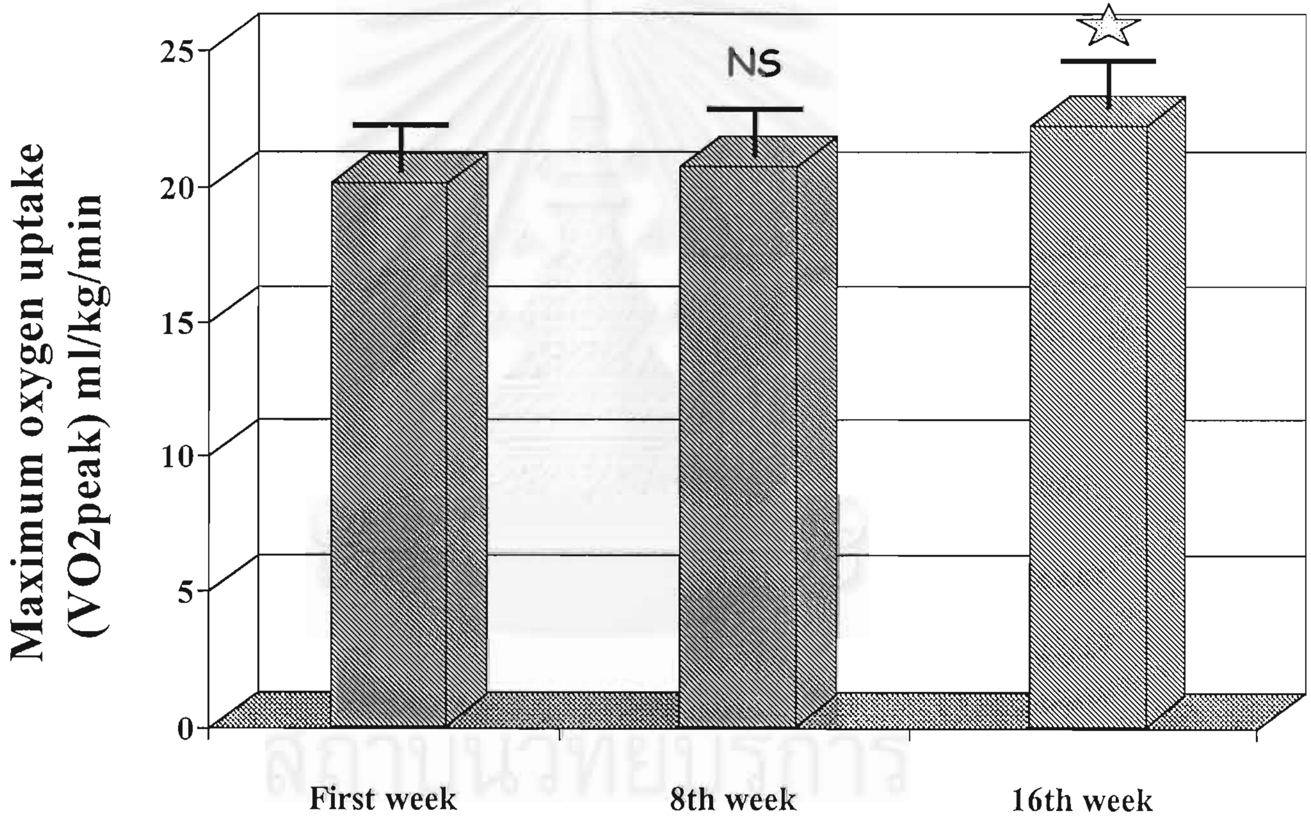


☆ Significant difference as compare to baseline measurement

NS No significant difference as compare to baseline measurement

44

Figure 4.4 Means and SD of relative oxygen uptake (VO2peak, ml/kg/min) at peak exercise test of type 2 DM subjects before and after 8 weeks, 16 weeks TCC training

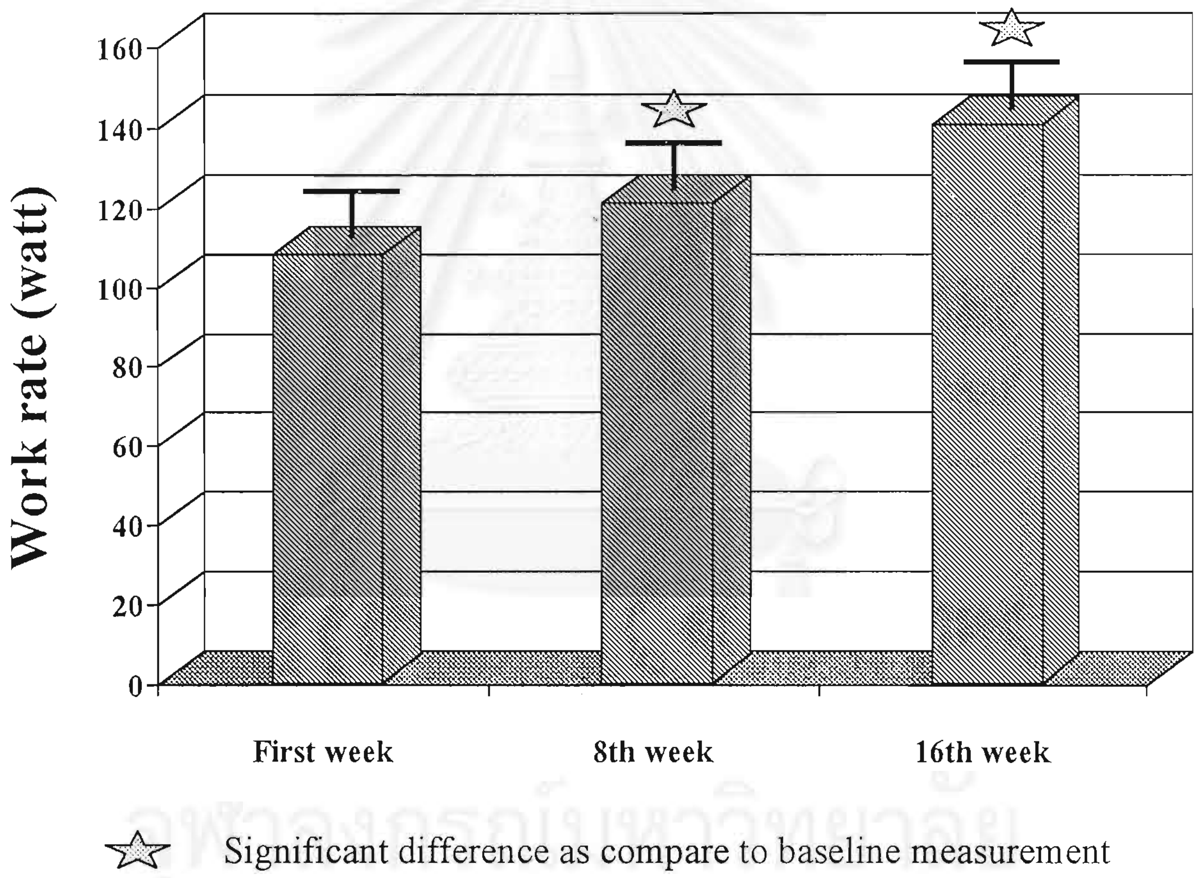


☆ Significant difference as compare to baseline measurement

NS No significant difference as compare to baseline measurement

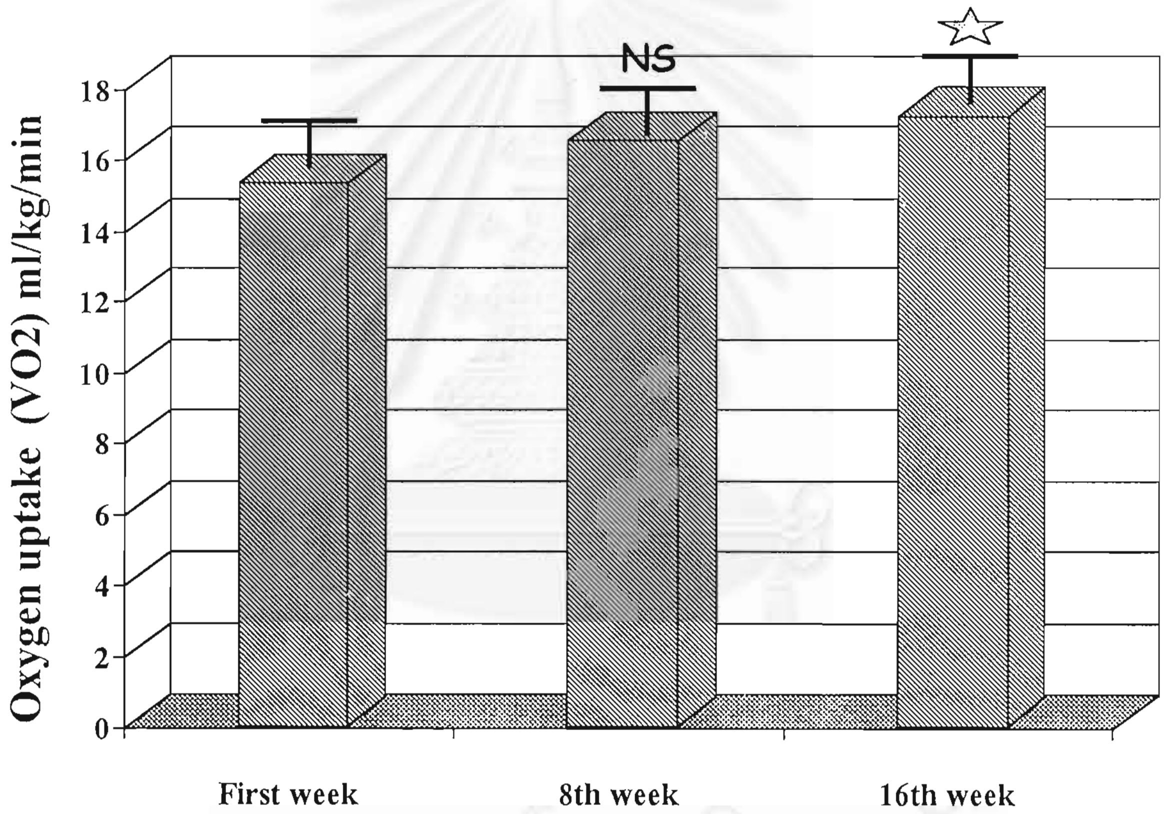
45

Figure4.5 Mean and SD of Work rate (watt) at peak exercise test of type 2 DM subjects before and after 8 week, 16 week TCC training



46

Figure 4.6 Means and SD of relative oxygen uptake (VO2peak, ml/kg/min) at ventilatory threshold of type 2 DM subjects before and after 8 weeks, 16 weeks TCC training

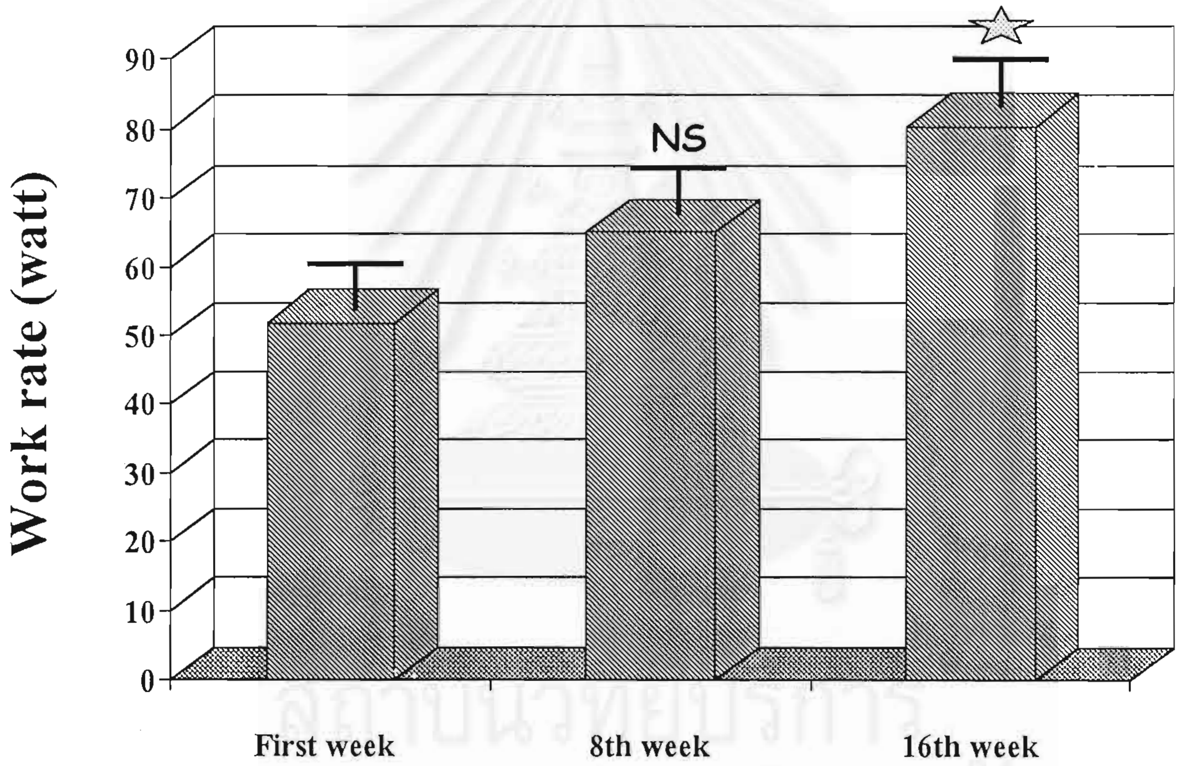


☆ Significant difference as compare to baseline measurement

NS No significant difference as compare to baseline measurement

47

Figure 4.7 Mean and SD of Work rate (watt) at ventilatory threshold of type 2 DM subjects before and after 8 week, 16 week TCC training



☆ Significant difference as compare to baseline measurement

NS No significant difference as compare to baseline measurement

CHAPTER V

DISCUSSION AND CONCLUSION

Type 2 diabetes mellitus is a major and increasing cause of global mortality, morbidity and healthcare expenditure. It is not only financial, but included psychological costs of everyday living as well. A patient with diabetes faces psychological problems like job discrimination; their lifestyle are limited and restrictive (Amos et al., 1997; Brown et al, 1999; Ty Willing, 1999). The aim of treatment intervention for the type 2 DM is not only to delay complication but also to improve the quality of life and increase the length of life. Therefore, patients with type 2 DM are recommended to lifestyle changes (Ruggiero et al., 1997). Because the diabetes-related complications are believed to result from chronic hyperglycemia, it can be prevented on delayed in their progressive by normalizing blood glucose level. The normalization of blood glucose is a very important therapeutic goal by diet, exercise, oral hypoglycemic drug or insulin if necessary (Horton, 1994; Herry, 1996; Araki and Ito, 1999).

Exercise has been considered a cornerstone in the treatment regimen for patients with type 2 DM. But the onset of type 2 DM usually occurs in middle-aged or elderly people. Thus, mode of training are accessibility, convenience, preference and influential factor in exercise participation by the elderly. In addition, these training are generally considered as a safe and appropriate for patients (Gordon, 1995). For example, low to moderate intensity exercise is more suitable for the unfit and elderly patients (Kligman and Pepin, 1992; Swift et al., 1995; Lehmann and Spinas, 1996). Moreover, elderly patients with type 2 DM prefer to mind-body exercise with low velocity which easy to learn and convenient to practice. Therefore, TCC Chinese traditional conditioning exercise deserves more attention owing to the training style is suited for the elderly patients with type 2 DM. Because of convenient, low cost, low impact, and safe, TCC is a suitable exercise (Kirstens et al, 1991; Wolf et al., 1997; Lan et al., 1999). In addition, a group exercise program with supervision is important for active participation. In the present study, the subjects also showed better compliance as well as felt a great interest in the TCC exercise because its form is full of variety and peer-group encouragement. All subjects completed the study. There was no complications or injuries during TCC exercise. Hypoglycemia was closing monitored by capillary blood glucose after each session of TCC exercise.

In the recent years, the emphasis in TCC has become far more focused on health promotion (Blair and Garcia, 1996; Lan et al., 1999). According to the ACSM, the following criteria for an endurance exercise are recommended: 1) the mode of activity should use large muscle groups, be maintained for a prolonged period, and be rhythmic and aerobic in nature; 2) the intensity of physical activity should correspond to 55/65 to 90 percent of maximal heart rate, 3) exercise duration should be 20 to 60 minutes of aerobic activity; and 4) exercise frequency should be 3 to 5 days per weeks. Even so, many health benefits from physical activity can be achieved at lower intensities of exercise if frequency and duration of training are increased appropriately (ACSM, 1998).

In this study, patients with type 2 DM subjects practiced TCC three times per week. Duration was approximately 1 hour per session (including warm up and cool down). The exercise intensity during the performance TCC exceeded 70 per cent of the HR at peak exercise. These results imply that the TCC exercise is moderate exercise intensity and aerobic in nature. All these characteristics fulfilled the criteria as recommended by ADA (1993) and ACSM (1998).

Adequate musculoskeletal flexibility is required for activity of daily living. However, most adults lose a significant amount of flexibility after their middle-age years (Einkauf et al, 1987). In addition, flexibility in persons with diabetes can be impaired if muscle collagen become glycate. Maintenance of flexibility in the lower back and hamstrings is especially important because lack of flexibility in these areas is associated with an increase risk for lower back pain. From the previous studies, it demonstrated that the TCC subjects had better trunk flexibility in comparison between before and after exercise (Lai et al., 1995; Lan et al., 1996). In the present study, the TCC subjects showed a significant increase of trunk flexibility 31 per cent after 8 week and 53 per cent after 16 weeks of exercise. The result may be attributed to 1) the effects of routine stretching exercise in the warm-up phase and 2) some stretching exercise that are harmoniously integrated in the motion of TCC.

Aging and chronic disease such as diabetes are associated with increased body weight and body fat. Inactivity and reduce basal metabolic rate may be the main contributing factor (Horton, 1994). In the pervious studies, they have demonstrated that the benefit of exercise combined diet kept constant had lower percentage of body fat or may induce reduction of body weight substantially (Wing, 1989; Blonk et al., 1994; Poirer, 1996). In this study, nevertheless, the TCC subjects showed no difference in body weight and body fat. Most studies of persons with type 2 DM undergoing physical training reported a significant decrease in plasma triglyceride levels and very low-density lipoproteins (Raz,1994; Schneider et al., 1992; Dunton et al., 1997). In contrast, this study is no change in cholesterol, LDL, HDL-cholesterol and slightly decrease in triglyceride but no significance after 16 weeks of TCC exercise. Actually, exercise training has not been consistently found to result in decrease in body weight, per cent body fat and significantly change in lipid profile in subjects. It may be because the exercise required to those effects is of a greater intensity than

TCC exercise or this study may not conduct long enough to realize those benefit. In addition, this is possible that it may be associated with relatively small sample size in this study, and no restrict calories of food intake through the training program.

Table 4.2 indicates that there were a significant change in fasting plasma glucose (FPG) and glycosylated hemoglobin (HbA1c) post 16 weeks of TCC exercise. It is a biochemical index attain criteria of ADA (ADA, 1998). These results is accordance with findings effect of a single exercise session in persons with type 2 DM which results in lower blood glucose concentrations. The acute decrement in plasma glucose levels leads to the improvements in glucose metabolism (Schneider, 1986; King, 1995; Braun, 1996; Usi et al, 1998), possibly related to an increment in insulin sensitivity in effect of prolong exercise (Vaninen, 1992; Raz, 1994; Dunton, 1997). In addition, physical activity exerts pronounced effects on substrate utilization and insulin sensitivity, which in turn potentially lower blood glucose (Walberg et al., 1998). Moreover, despite of without the recommendation of diet, some subjects was adjusted to low dose of oral hypoglycemic drug during study period. Thus, it implies that increased physical activity by TCC exercise can help patients to better glycemic control.

It is generally accepted that aerobic training may elicit a significant increase of cardiorespiratory function in elder subjects (Seal et al., 1984; Posner et al., 1992; Binder et al., 1996). Exercise training is effective to improve physical capacity in patients with type 2 DM (Poirer et al., 1996; Dunston et al., 1997; Ligtenberg et al., 1997). Maximal oxygen uptake, which is determined by the capacity of the cardiovascular system to deliver oxygen to the working muscles, has been used as an index of overall maximal cardiovascular functional capacity (Wasserman et al., 1994; McArdle et al., 1996; Poole et al., 1997), However, true maximal VO2 is difficult to obtain in the elderly. In present study, we expressed maximal exercise capacity by using the peak O2 attained. The TCC type 2 DM subjects showed 11 percent higher VO2 peak in comparison between before and after TCC exercise. These data showed that TCC exercise is beneficial to maximal cardiorespiratory function in the elderly. Furthermore, the TCC subjects showed higher maximal work rate than baseline, which implied that the TCC practitioners had a greater ability to perform work.

Ventilatory Threshold (VeT) is an indicator of aerobic endurance during submaximal work and used to evaluate the individual's aerobic potential and the effect of training. For the clinical application, VeT is thought to be a noninvasive measurement of the lactic threshold (LT). It identifies the oxygen uptake at the onset of a metabolic acidosis. It can be detected invasively by measurement of blood lactate or estimated noninvasively by measurement of the gas exchange (Chen et al, 1992. Wasserman, 1994; Davis, 1997). LT represents the workload at which the cardiovascular system fails to supply adequate oxygen to the tissue. When assessing one's endurance, the LT or VeT is considered to be a sensitive indicator of physical performance. In the present study, the type 2DM subjects showed significantly higher VO2, and work rate at the VeT. The result implied that long-term TCC exercise might improve endurance during exercise at submaximal work rates.

In conclusion, several reasons from the standpoint of exercise prescription and our data indicate that long-term practice of TCC may benefit for patients with type 2 DM. **Firstly**, TCC is effective for improving glycemic control, cardiorespiratory fitness and other fitness traits **Secondary**, TCC can easily incorporate into daily living. **Thirdly**, the patients can practice anytime and anywhere, eventually to follow the TCC exercise at home safety. Type 2 DM patients should undergo a through medical evaluation prior to increasing physical activity. Particularly, for most older patients, the adoption of moderately active lifestyle may carry important health benefits and may be a more attainable goal than the achievement of high level of fitness (ACSM, 1998). Habitual physical activity may increase functional ability and, thus, ameliorate capacity for independence by decreasing the need for assistance in the activity of daily life (Posner et al, 1992). Furthermore, it may reduce medical expenditure. The practice of TCC may be suitable and might reasonably be prescribed as a good alternative conditioning exercise for elderly patients with type 2 diabetes mellitus.

In further study, the experiment should have the control group and increase the number of subjects. In addition, the timing of study period should be increased and perform the result of follow-up.

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APPENDICES

APPENDIX A

About HbA_1c

The pigment that makes our blood red is a protein called hemoglobin (Hb). There are many types of Hb, with HbA being the major one. Glucose enters the blood cells readily and can add onto to HbA_1c. In so doing, it changes the structure and charge of HbA_1c and produces a modified protein, called a glycohemoglobin. There are about 5 different glycohemoglobins, but HbA_1c is the major one. The amount of HbA_1c that forms is proportional to the blood glucose. The higher the glucose, the faster the HbA_1c is formed. Once formed, the HbA_1c lasts for the entire life span of the blood cell.

The average life span of red blood cells is about 120 days. During this time, the HbA_1c in the red blood cells is continuously exposed to glucose. The higher the average blood glucose level, the higher the HbA_1c level will be. So people with diabetes will have higher HbA_1c in their blood because they have a higher average blood glucose level. We also know that people with diabetes in poor control have higher HbA_1c than people with diabetes in good control. The HbA_1c predicts the chances of developing eye, kidney and nerve complications of diabetes in those who do not have these complications yet; it also indicates the chances of progression of these same complications in those who already have them (McCane et al., 1991)

APPENDIX B

Major Components of the Pre-exercise Medical History

Individuals should be questioned about a past or present history of the following:

- Heart attack, coronary angioplasty, bypass surgery, other cardiac surgery
- Pain or discomfort in the chest or surrounding areas that maybe ischemic in nature
- Light-headedness or syncope, particularly with exercise
- Unaccustomed shortness of breath or shortness of breath with mild exertion
- Palpitations or tachycardia
- Symptoms of congestive heart failure
- Heart murmurs, clicks, or other unusual cardiac findings
- Hypertension
- Stroke or transient ischemic attacks
- Phlebitis, emboli
- Symptoms and laboratory test results related to diabetes
- Current treatment of diabetes, including medications, diet, and results of glucose monitoring
- Frequency, severity, and cause of acute diabetes complications, such as ketoacidosis and hypoglycemia
- Symptoms and treatment of chronic complications associated with diabetes (eye, heart, kidney, nerve, peripheral vascular and cerebral vascular)
- Pulmonary disease, including asthma, emphysema, and bronchitis

- Abnormal serum lipids and lipoproteins
- Anemia
- Emotional disorders
- Recent illness, hospitalization, or surgical procedure
- Pregnancy and breast-feeding
- Medications of all types
- Drug allergies
- Musculoskeletal disorders and injuries
- Family history, in particular, coronary heart disease and sudden death
- Habits, such as tobacco use, alcohol use, caffeine use, and eating disorders
- Exercise history with information on available resources, personal preferences, environmental considerations, and exercise type, frequency, duration, and intensity
- Psychosocial and economic factors that might influence the precise nature of the exercise prescription

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Adapted with permission from the American College of Sports Medicine (1991) and from the American Diabetes Association (1993)

APPENDIX C

Summary of Exercise Recommendations for Patients With Diabetes

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1. Screening

- Search for vascular and neurological complications, including silent ischemia
- Exercise ECG in patients with known or suspected CAD, or > 35 years of age with type 2 diabetes

2. Exercise program

- Type: Aerobic
- Frequency: 3-5 times/week
- Duration: 20-60 min
- Intensity: 40-70 % of maximal aerobic capacity
- Energy expenditure: Modulate type, frequency, duration, and intensity to attain an energy expenditure of 700-2,000 calories/week
- Timing: Time participation so that it does not coincide with peak insulin absorption

3. Avoid complications

- Warm up and cool down
- Careful selection of exercise type and intensity
- Patient education
- Proper footwear
- Avoid exercise in extreme heat or cold

- Inspect feet daily and after exercise
- Avoid exercise when metabolic control is poor
- Maintain adequate hydration
- Monitor blood glucose if taking insulin or oral hypoglycemic agents, and follow guidelines to prevent hypoglycemia

4. Compliance

- Make exercise enjoyable
- Convenient location
- Positive feedback from involved medical personnel and family

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Adapted in part from the American Diabetes Association (1993)

BIOGRAPHY

Pol. Maj. Chaweewan Deechauy was born Jan 31, 1967 in Nakornnayok, Thailand. She graduated Bachelor of Nursing Science from Police Nursing College in 1989. She is working at Police General Hospital.