British Journal of Medicine & Medical Research
4(32): 5083-5097, 2014

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The Effects of Supervised Exercise Program on Health-Related Physical Fitness in Kuwait

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Authors' contributions

This work was carried out in collaboration between all authors. Author FA designed the study, wrote the protocol, and supervised the study conduct. Author KS collected the data, performed the statistical analysis, and wrote the first draft of the manuscript. Authors OA and MTB collected the data. Author KB supervised the team in the manuscript preparation. All authors read and approved the final manuscript.

Original Research Article

Received 14th May 2014
Accepted 30th June 2014
Published 10th July 2014

ABSTRACT

Aims: Physical activity improves health in terms of cardiovascular fitness, musculo-skeletal fitness, body composition, and metabolism. The study aims to examine the effects of supervised exercise training on metabolic profile and health-related physical fitness parameters in Kuwait.
Study Design: A prospective observational study.
Place and Duration of Study: Fitness and Rehabilitation Center (Dasman Diabetes Institute, Kuwait) between January 2012 and December 2013.
Methodology: We included 90 participants (44 women), mean age 48.6 (±14.4) years with adherence exceeding 50%. Outcome measures health-related physical fitness (measured by cardiopulmonary exercise testing) and other secondary outcome measures including anthropometric data, vital signs, and glycemic profile values.
Results: Paired t-test was used to evaluate the effects of exercise training. Both diabetic and non-diabetic participants showed significant increase in peak oxygen consumption (3.0 $ml \cdot min^{-1} \cdot kg^{-1}$; 95% CI: 2.3 to 3.7; $p < 0.001$). There was significant reduction in BMI (-0.6 kg/m^2; 95% CI: -0.9 to -0.3; $p < 0.001$), waist circumference (-2.2cm; 95% CI: -3.4 to -1.0; $p = 0.002$) and body fat percentage (-0.9%; 95% CI: -1.4 to -0.3; $p = 0.002$). The

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glycated hemoglobin significantly decreased (*p*=0.001). Fasting blood glucose and lipid profile improved but were not statistically significant. The exercise intervention reduced the systolic blood pressure (BP) and diastolic BP by a mean of 0.6 (95% CI: -3.2 to 1.9; *p* = 0.63) and 2.6 mmHg (95% CI: -4.9 to -0.3; *p*=0.03) respectively, with the latter being statistically significant. Significant changes were also noted in variables of total handgrip (4.2 kg; 95% CI: 1.4 to 7.0; *p*=0.04) and push-up (4.2 repetition; 95% CI: 1.9 to 6.4; *p* < 0.001).

Conclusion: The 12-week supervised exercise intervention used seems to improve cardiorespiratory fitness, glycemic control, diastolic BP and anthropometric measurements. This improvement can indicate that exercise decrease cardiovascular events and mortality.

Keywords: Exercise; Health-related Physical Fitness; Kuwait.

1. INTRODUCTION

During the past 3 decades, the widespread socio-economic development and progressive urbanization in Kuwait had caused dramatic changes in individuals' lifestyles such as physical activity patterns and eating habits. These resulted in increased caloric intake and concomitant decreased physical activity [1,2], as well as a considerable negative impact on social health. Eventually, an epidemic of chronic non-communicable diseases such as obesity, diabetes mellitus (DM), and hypertension (HTN) has been reported [3,4].

A community-based national study in 2008 showed that the overall prevalence of DM and coronary artery disease (CAD) have reached 11.2% and 2.9%, respectively. The study also showed that non-communicable diseases are collectively estimated to account for 76% of all deaths in Kuwait [4,5].

Addressing physical activity is a milestone in the prevention of non-communicable diseases. Physical inactivity is an independent risk factor for a number of chronic diseases including CAD, type 2 DM (T2DM), HTN, obesity, and osteoporosis. Global estimates have shown that physical inactivity results in approximately 30% of CAD cases and in 27% of all of T2DM. Physical inactivity can potentially lead to breast, colon, and rectal cancer [3]. Observational studies have shown that regular physical activity is associated with a lower risk of all-cause mortality and a reduced risk of developing T2DM, osteoporosis, and certain types of cancer. In addition, evidence suggest that physical activity enhances psychological wellbeing [3,6,7]. Most recent recommendation advise people of all ages to include a minimum of 30 minutes of moderate intensity (e.g. brisk walking) on 5 days each week or a minimum of 20 minutes of vigorous intensity (e.g. jogging causing rapid breathing and substantial increase in heart rate) on 3 days each week. In addition, every adult should perform activities that increase muscular strength and endurance a minimum of 2 days each week [3,7].

In contrast to physical activity, which is related to bodily movements that result in energy expenditure above a resting state, physical fitness that results from intended physical activity affects a variety of factors related to health status such as cardiovascular fitness, musculo-skeletal fitness, body composition, and metabolism. Physical fitness is defined as a set of characteristics individuals have or achieve that is related to their ability to perform physical activity. These characteristics are divided into health-related (cardiorespiratory endurance, body composition, flexibility and, muscular strength and endurance) and skillrelated (agility, coordination, balance, power, reaction time and speed) components of physical fitness. Health-related physical fitness is a common measurement in preventive and rehabilitative exercise programs [8-11]. With respect to morbidity and mortality, the effects of physical fitness are similar to those of physical activity; however physical fitness is a stronger predictor of health outcomes. Routine physical activity has shown to improve health outcomes such as improvement in body composition, lipid profiles, glucose homeostasis, insulin sensitivity, autonomic tone, coronary blood flow, endothelial function, reduced blood pressure (BP), and systemic inflammation and blood coagulation [12-14].

The published reports on physical activity among the population of Kuwait indicate that the majority of individuals are not physically active to the extent required to achieve health benefits. The overall prevalence rate of low level physical activity in Kuwait was 63%, higher in women than in men (71.3 vs. 58.0%) [2,4,5]. Hence, physical activity is emphasized in health promotion and disease prevention campaigns in Kuwait to promote optimal health.

Evidence from multiple observational studies overwhelmingly illustrates the beneficial impact of exercise on cardiovascular health and T2DM control [15-25]. The purpose of this study was to examine the effects of 12-week supervised training on metabolic profile and health-related physical fitness parameters in adult participants.

2. MATERIALS AND METHODS

2.1 Study Participants

The study participants were selected from individuals enrolled to the Exercise Program (ExP) at the Dasman Diabetes Institute (Kuwait) between January 2012 and December 2013. All included individuals were above 14years old. Participants were enrolled to undergo a detailed medical evaluation by a physician including their past medical history and exercise tolerance. All individuals with either physical or psychological health conditions that may possibly interfere with their ability to perform the requested exercise and concurrent cardiopulmonary exercise testing (CPET) were excluded from the study. Exclusion criteria also included pregnancy and inability to perform the CPET. For individuals to be included in the post-intervention analysis, they have to adhere to the 12-week exercise program with an attendance record of at least 3 days per week.

2.2 Exercise Intervention

The ExP is an evidence-based intervention, which includes an exercise program designed to improve functional capacity, promote lifelong physical activity, and enhance the overall quality of life. The ExP includes supervised aerobic, including water exercises and resistance training. When studied in basic science literature, we found that the ExP restores the expression of DNAJB3 gene in obese subjects, which can potentially play a protective role against obesity [26].

All participants were enrolled to complete 12 weeks of supervised exercise training as recommended by the American College of Sports Medicine [8] and Your Prescription for Health, Exercise is Medicine® guidelines [9]. The exercise training involves a combination of both moderate intensity aerobic exercise aiming for a target heart rate (THR) range of 65-80% of maximal HR achieved at peak oxygen consumption (peak VO_2) and resistance training of 15 repetitions for 2 to 4 sets. The participants spend 30 minutes on each training session. Regular monitoring of the heart rate during the aerobic training was ensured to maintain the THR.

Participants of the study received exercise prescriptions that primarily included aerobic exercises. These were activities that require minimal skills such as walking, running, dancing, cycling (upright and recumbent bikes), arm cycling, arc training, elliptical machine, stepping machine rowing, spinning, and aqua aerobics. Non-weight bearing machines and aqua-based aerobic exercises were recommended for participants with musculoskeletal limitations. Strength training was performed 2 to 3 times a week and consisted of either a total body workout or a split-programming workout. Strength training focused on more than one muscle group including chest and shoulder press, latissimus dorsi muscle pull down, lower back extension, abdominal crunch, and leg press. Single joint exercises targeting major muscle groups consisted of quadriceps muscle extension as well as biceps, triceps and hamstring muscles curl. Strength exercises that are contraindicated for certain health conditions or physical disabilities were modified accordingly. Fitness instructors supervised all training sessions to ensure correct technique and proper amount of exercise performed with adequate frequency of rest intervals taken. Capillary blood glucose (CBG), HR, and BP were assessed prior to and after the training session. Only participants who exercised at least three days per week were included in the study.

2.3 Outcomes

Participants underwent baseline anthropometrics measurements, vital signs, blood analysis, body composition, CPET, and further physical fitness assessment. The measurements were repeated after 12 weeks of supervised exercise intervention. Written informed consent was obtained from all participants before the CPET procedure. All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 declaration of Helsinki.

The study's primary outcome measure is cardiorespiratory fitness, measured by the CPET. Our secondary outcomes were other health-related physical fitness measurements including body composition, handgrip strength, muscular strength and endurance, and flexibility testing. We also evaluated participants' anthropometric data, vital signs (CBG, HR, and BP), and basic blood analysis. Further details of some of the outcomes are as follows:

2.3.1 Health-related physical fitness

The health-related physical fitness assessments are divided into 5 components:

2.3.1.1 Cardiorespiratory fitness

The cardiorespiratory fitness was measured while undergoing a symptom-limited maximal incremental CPET using an electromagnetically braked cycle ergometer (Ergoline®) by increasing the workload in a ramping pattern. The CPET was performed at the beginning of the study to assess aerobic endurance, identify the source of exercise limitation, and determine the adequate range of THR for exercise prescription. The test was repeated after 12 weeks upon completion of the exercise program. To begin with the test, the participant's mouth and nose were covered with a sterilized face mask which was connected to a metabolic cart (COSMED Quark CPET®). The cart contains a flow meter and gas analyzers which analyzes oxygen intake and carbon dioxide output using breath-by-breath computerbased system. Testing protocol starts with two minutes of rest, followed by two minutes of unloaded cycling, after which workload was increased in a ramping mode at a rate of 5 to 15 Watts per minute. The ramping protocol was adjusted according to participant's age and medical background. Participants were instructed to maintain the pedaling rate at 55 to 60 rate per minute until they reach maximal exhaustion. and finally completes with 3 to 5 minutes of recovery stage. The electrocardiography (ECG) and BP were monitored continuously. In the absence of chest pain, dizziness and significant ECG abnormalities, all tests were continued as symptom-limited (volitional exertion by dyspnea or fatigue). All tests were conducted by the CPET laboratory biomedical engineer, a nurse and a supervising physician. Peak VO_2 was used as the functional capacity [10,27].

2.3.1.2 Body composition

After 4 hours of fasting, total body fat of each participant was measured using the body composition analyzer (Analyzer iOi353®). The percent body fat (%) was determined as the percentage of adipose tissue in the body. Another parameter used was lean body mass which represents the weight of muscle.

2.3.1.3 Handgrip strength

Handgrip strength was measured using isometric dynamometers (Baseline® Digital Hydraulic Hand Dynamometer). The participants held the dynamometer in the hand to be tested, with the arm flexed at ninety degrees and the elbow by the side of the body. The dynamometer's base should rest on first metacarpal (heel of palm), while the handle should rest in middle of four fingers. Participants were instructed to squeeze the dynamometer with maximum isometric effort, maintaining the technique for about 5 seconds with no other body movement. The best result from several trials (up to 3) for each hand was recorded, with at least 15 seconds recovery between each effort. Best total of both hands was counted as the score [8,10,11].

2.3.1.4 Muscular strength and endurance

Push-up test was administered as standard push-up position for men and modified knee-push-up position for women. Standard push up was started with the "down" position with hand pointing forward and under the shoulder, back straight, head up, and using the toes as the pivotal point. The participants were asked to raise the body by straightening the elbow and return to the "down" position. Proper technique was constantly observed by making sure that the chest is a fist away from the floor. Modified "knee push up" position was started with lower leg in contact with the mat and ankles planter-flexed, back straight, hands shoulder width apart, head up and using the knees as the pivotal point. Similarly, they were asked to raise the body and return to the initial position. Each participant was timed for one minute (or as managed) and total repetitions were recorded.

Half sit-up test was administered in supine position with both knees bent and palms facing down,. Participants were asked to lift-off shoulder blade from the floor as in performing crunches (the chin should not reach towards the chest and space was maintained between chin and chest area). Participants were instructed to perform as many repetitions as possible in one minute and total repetitions were recorded [8,10,11].

2.3.1.5 Flexibility

Forward bending test was done in a long-sitting position. The tape measure was positioned between the legs with the “0” part of measuring tape starting from the foot. Participants were asked to bend forward with both hands as far as possible without allowing the knees to be bent and the most distant point reached with the finger tips was measured. This assessment was carried out with caution as overstretching of muscles can occur. The test was contraindicated in participants with disc problems. The best measurement of three trials was recorded [8,10].

2.3.2 Anthropometric measures

Each participant’s body mass index (BMI) was extrapolated from measured body weight and height. BMI was calculated by dividing body weight (kg) by height in metres squared (m^2). The waist circumference was measured at the narrowest waist level, or if this is not apparent, at the midpoint between the lowest rib and the top of the hipbone (iliac crest). Hip circumference was measured at the level of the greatest protrusion of the gluteal muscles. The waist to -hip ratio is the circumference of the waist divided by the circumference of the hip [10,11]. All the measurements were done by the same study personnel.

2.3.3 Blood analysis

Fasting blood samples were collected by experienced phlebotomist after 10 hours of fasting from the night before. The blood samples include fasting blood glucose (FBG), total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, triglyceride and glycated hemoglobin (HbA1c). All samples were analyzed in the biochemistry laboratory at Dasman Diabetes Institute.

2.4 Statistical Analysis

The sociodemographic data were analyzed using descriptive statistics and presented as mean ± standard deviation (SD). To evaluate the effects of exercise training, paired t-test was used to measure the differences in change from baseline to post-intervention for the participants. Statistical significance was set at $p < 0.05$ and results are presented as a mean difference with 95 percent confidence interval (95% CI). All statistical analyses were performed using SPSS software (version 19.0).

3. RESULTS AND DISCUSSION

Of the 90 participants with acceptable attendance records, 58 repeated the CPET after 12 weeks, and 46 had second blood tests. All 90 participants exercised at least 3 days per week with no serious adverse effects reported. The 32 participants who were excluded from the analysis refused for a repeat CPET after 12 weeks. Moreover, 12 of the 58 participants who repeated the CPET did not agree for a repeat blood analysis (Fig. 1).

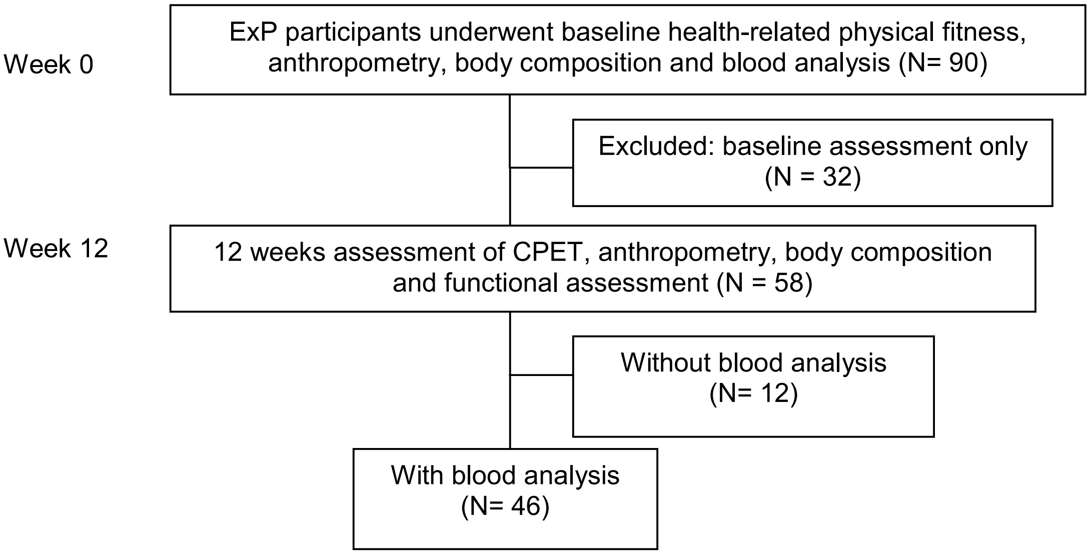

Fig. 1. Participants flow diagram of participants with satisfactory attendance

Participants' mean age was 48.6 (±14.4) years, with 51% males. At the time of enrolment to the study 90% of them had a BMI of more than 25kg/m². The mean body fat percentage was 35.1%. Among the 90 participants, 48% suffered from T2DM and 32% had HTN. The prevalence of hyperlipidemia and CAD was 57 and 9%, respectively. The mean HbA1c in the enrolled participants was 6.6%. Peak VO_2 measured at the baseline CPET was 17.6±4.2ml·min^{-1}·kg^{-1}. Table 1 illustrates more detailed baseline characteristics including metabolic markers and fitness assessments.

Table 2 shows the comparative values of anthropometric, vital signs, glycemic control, metabolic profile and cardiovascular fitness parameters at baseline and upon completion of 12 weeks of exercise intervention. Both diabetic and non-diabetic participants showed significant increase in peak VO_2 (3.0ml·min^{-1}·kg^{-1}; 95% CI: 2.3 to 3.7; *p* < .001). The baseline exercise capacity was noted to be lower in diabetic participants compared to non-diabetic participants (16.2±4.2 vs 19.3±4.7ml·min^{-1}·kg^{-1}) (Fig. 2-A). In terms of percentage, diabetic participants showed 11% increase (1.6 ml·min^{-1}·kg^{-1}; 95% CI: 0.7 to 2.6; *p*=.001) and non-diabetic participants showed 20% increase (4.5ml·min^{-1}·kg^{-1}; 95% CI: 3.5 to 5.7; *p*<0.001) in peak VO_2 levels. There was significant reduction in BMI (-0.6kg/m^2; 95% CI: -0.9 to -0.3; *p*<.001), waist circumference (-2.2cm; 95% CI: -3.4 to -1.0; *p* =.002) and body fat percentage (-0.9%; 95% CI: -1.4 to -0.3; *p*=.002). The HbA1c significantly decreased (*p*=.001) and was distinct among the diabetic participants with 7% reduction (-0.54%; 95% CI: -0.78 to 0.30; *p*<.001), meanwhile no difference was noted among the non-diabetic participant (-0.02%; 95% CI: -0.09 to 0.07; *p*=.66) (Fig. 2-B). Although levels of fasting blood glucose (-0.3 mmol/l; 95% CI: -0.7 to 0.1; *p*=.10) and lipid profile , including total cholesterol (-0.2mmol/l; 95% CI: -0.4 to 0.1; *p*=.12), HDL-cholesterol (0.03 mmol/l; 95%CI: -0.02 to 0.08; p=.21), LDL-cholesterol (-0.15 mmol/l; 95% CI: -0.32 to 0.03; *p*=.09) , and triglycerides (-0.11 mmol/l; 95% CI: -0.37 to 0.16; *p*=.42), improved after the intervention but these changes were not statistically significant. The exercise intervention reduced the systolic BP and diastolic BP by a mean of 0.6 (95% CI: -3.2 to 1.9; *p*=.63) and 2.6 mmHg (95% CI: -4.9 to -0.3; *p*=.03) respectively, with the latter being statistically significant (Fig. 2-C). Significant changes were also noted in variables of total handgrip (4.2 kg; 95% CI: 1.4 to 7.0; *p* = .04) and push-up (4.2 repetition; 95% CI: 1.9 to 6.4; *p*<.001).

Table 1. Baseline characteristics of participants

Characteristic	**Participants (n =90)**	
Gender, No. (%)	**Male 46 (51.1)**	**Female 44 (48.9)**
Age, yr, mean (SD)	49.6 (16.7)	47.7 (11.8)
Nationality, No. (%)		
Kuwaiti	30 (65.2)	33 (75.0)
Other Nationality	16 (34.8)	11 (25.0)
Medical History, No. (%)		
Type 2 Diabetes Mellitus	24 (52.2)	19 (43.2)
Hypertension	18 (39.1)	11 (25.0)
Hyperlipidaemia	28 (60.9)	23 (52.3)
Coronary artery disease	5 (10.9)	3 (6.8)
Anthropometrics, mean (SD)		
Weight, kg	94.8 (23.5)	78.3 (19.6)
BMI, kg/m^2	31.8 (6.4)	30.4 (5.6)
Waist Circumference, cm	107.6 (13.2)	96.7 (14.4)
Hip Circumference, cm	113.7 (15.2)	110.6 (11.9)
Waist-to-Hip Ratio	0.95 (0.07)	0.87 (0.08)
Presence of Overweight or Obesity, No. (%)		
Body Mass Index 25-29.9	17 (37)	17 (38.6)
Body Mass Index ≥30	22 (48)	16 (36.4)
Vital signs, mean (SD)		
Systolic BP, mmHg	124.1 (10.6)	120.7 (12.9)
Diastolic BP, mmHg	74.3 (7.7)	69.8 (8.7)
RHR, beats/min, mean (SD)	81.4 (14.2)	78.4 (10.3)
Cardiovascular Risk Factors, mean (SD)		
FBG, mmol/L	6.6 (1.8)	6.9 (2.6)
HbA1c (%)	6.6 (1.3)	6.6 (1.5)
Total Cholesterol, mmol/L	5.0 (1.1)	5.1 (0.9)
HDL Cholesterol, mmol/L	1.0 (0.3)	1.4 (0.4)
LDL Cholesterol, mmol/L	3.2 (0.9)	3.1 (0.8)
Triglyceride, mmol/L	1.7 (1.0)	1.5 (1.1)
Exercise Test Variables, mean (SD)		
Peak VO_2, ml/min	1677 (474)	1253 (324)
Peak VO_2 per weight, ml/min/kg	18.4 (4.0)	16.9 (4.4)
Functional Variables, mean (SD)		
Total Handgrip, kg	81.4 (19.8)	50.3 (11.1)
Sit-up, No. Repetitions	24.8 (13.3)	17.5 (15.7)
Push-up, No. Repetitions	6.3 (6.6)	4.7 (7.9)
Flexibility, cm	22.1 (15.2)	21.7 (15.0)
Body composition, mean (SD) [n= 82]*	**n=41**	**n=41**
Body Fat (%)	31.8 (4.4)	38.4 (4.8)
Lean Body Mass, kg	60.1 (8.7)	45.7 (6.4)

*where BMI=Body Mass Index, BP=Blood Pressure, RHR= Resting Heart Rate, FBG= Fasting Blood Glucose, HDL= High Density Lipoprotein, LDL=Low Density Lipoprotein, Peak VO_2=Peak Oxygen Uptake, * 8 participants without body composition values either due to the out of range measurements or the patient had metal insitu that precludes them from doing the test*

Table 2. Changes in anthropometric, vital signs, glycemic control, metabolic profile and cardiovascular fitness parameters at baseline and upon completion of 12-week exercise program

Variables	Baseline, mean (SD)	Week 12, mean (SD)	Mean difference (95% CI)	p-value
Anthropometrics (n=58)				
Body weight, kg	86.4 (21.3)	84.6 (20.6)	-1.7 (-2.6 to -0.9)	<0.001
BMI, kg/m^2	31.2 (6.1)	30.6 (5.9)	-0.6 (-0.9 to -0.3)	<0.001
Waist circumference, cm	102.3 (14.5)	100.0 (15.0)	-2.2 (-3.6 to -0.9)	0.002
Hip circumference, cm	112.0 (13.0)	109.8 (12.5)	-2.2 (-3.4 to -1.0)	<0.001
Waist-to-hip ratio	0.91 (0.09)	0.91 (0.09)	0.0 (-0.02 to 0.01)	0.74
Vital Signs (n=58)				
Systolic BP, mmHg	120.5 (11.4)	119.9 (10.6)	-0.6 (-3.2 to 1.9)	0.63
Diastolic BP, mmHg	71.8 (7.8)	69.2 (8.4)	-2.6 (-4.9 to -0.3)	0.03
RHR, beats/min	78.7 (12.0)	76.4 (11.7)	-2.3 (-4.8 to 0.3)	0.08
Glycemic and Metabolic profile (n=46)*				
CBG, mmol/L (n=27)†	7.4 (2.4)	6.9 (2.2)	-0.6 (-1.2 to 0.4)	0.66
FBG, mmol/L	6.3 (1.9)	6.1 (1.4)	-0.3 (-0.7 to 0.3)	0.10
HbA1c (%)	6.3 (1.3)	6.1 (1.1)	-0.2 (-0.3 to -0.1)	0.001
Total Cholesterol, mmol/L	4.9 (0.9)	4.7 (0.9)	-0.2 (-0.4 to 0.1)	0.12
HDL-cholesterol, mmol/L	1.2 (0.3)	1.2 (0.4)	0.0 (-0.02 to 0.08)	0.51
LDL-cholesterol, mmol/L	3.0 (0.8)	2.9 (0.7)	-0.2 (-0.32 to 0.03)	0.09
Triglyceride, mmol/L	1.6 (1.0)	1.5 (1.0)	-0.1 (-0.4 to 0.2)	0.42
Body Composition (n=52)‡				
Fat Percentage (%)	34.9 (5.8)	34.1(6.0)	-0.9 (-1.4 to -0.3)	0.002
Lean Body Mass, kg	53.6 (11.0)	53.5 (11.1)	-0.1 (-0.5 to 0.3)	0.58
Cardiopulmonary Exercise Test (n=58)				
Peak VO_2, ml/min	1540 (463)	1783 (596)	243 (176 to 310)	<0.001
Peak VO_2 per weight, ml/min/kg	18.02 (4.7)	21.0 (5.5)	3.0 (2.3 to 3.7)	<0.001
Functional Variables (n=58)				
Total Handgrip, kg	64.2 (23.5)	68.4 (23.3)	4.2 (1.4 to 7.0)	0.04
Sit-up, n	22.1 (15.1)	25.8 (15.7)	3.7 (-0.7 to 8.1)	0.10
Push-up, n	6.0 (7.7)	10.2 (9.8)	4.2 (1.9 to 6.4)	<0.001
Flexibility, cm	23.4 (15.5)	24.45 (15.4)	1.1 (-2.7 to 4.9)	0.57

*where BMI=Body Mass Index, RHR=Resting Heart Rate, BP=Blood Pressure, CBG= Capillary Blood Glucose, FBG= Fasting Blood Glucose, HDL= High Density Lipoprotein, LDL=Low Density Lipoprotein, Peak VO_2=Peak Oxygen Uptake, * Number of participants with repeat metabolic markers, † Number of diabetic participants with capillary blood sugar monitored during exercise, ‡ 6 participants without body composition values either due to the out of range measurements or the patient had metal insitu that precludes them from doing the test*

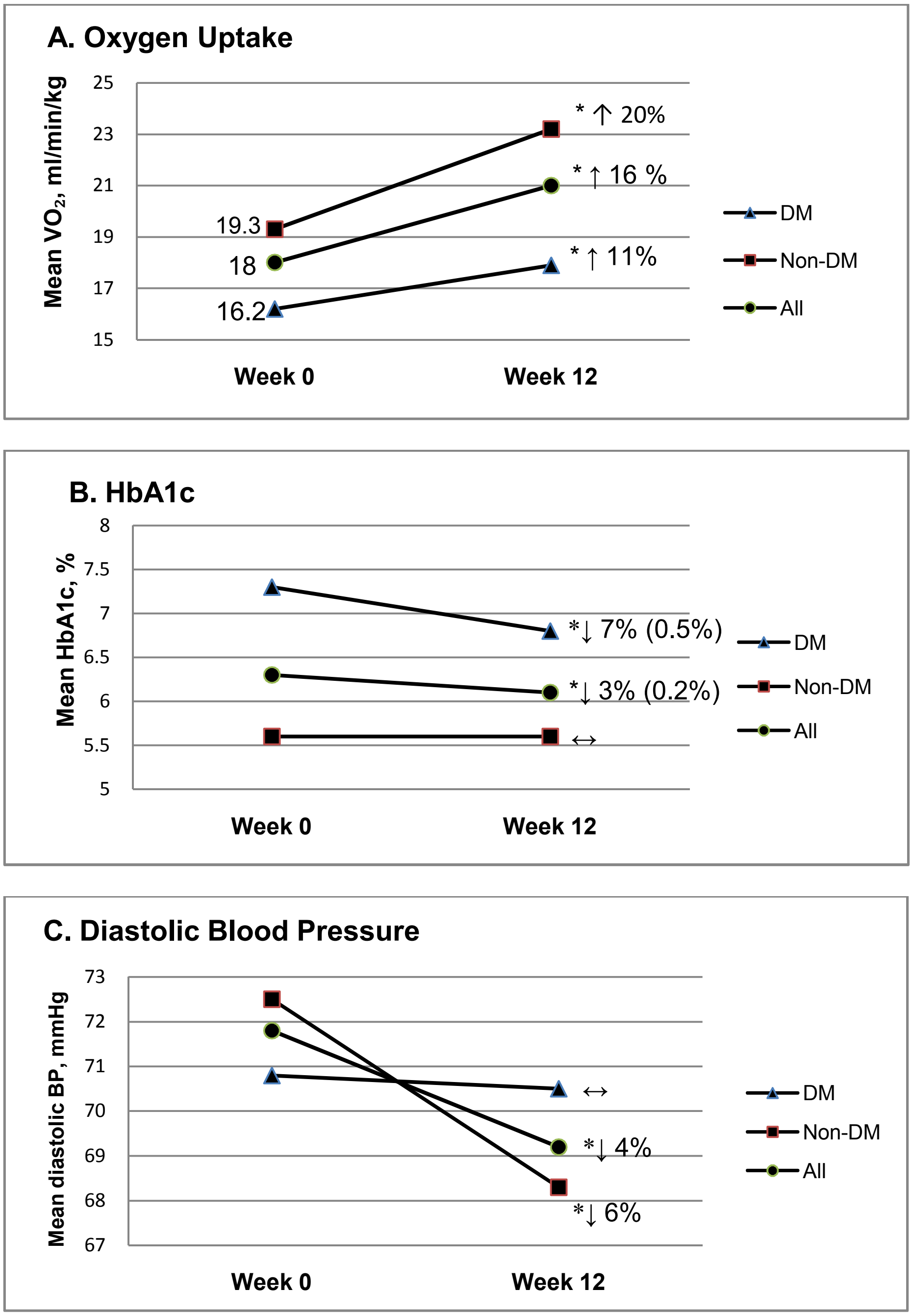

Fig. 2. (A-C) Changes in parameters at baseline and upon completion of 12-week supervised exercise training

** Statistically significant, p< 0.05*

The results of this study demonstrate that supervised exercise intervention which include aerobic and resistance training program performed at least 3 days per week for 12 weeks duration seems to be effective in improving cardiorespiratory fitness, glycemic control, diastolic BP and anthropometric measurements. These outcomes are known risk markers for all-cause mortality and cardiovascular events. Therefore, the study findings support the effectiveness of the supervised aerobic and resistance training for improving health and physical function. To our knowledge, this is the first study in Kuwait to evaluate objectiveness of physical activity and fitness.

Low levels of cardiorespiratory fitness have been associated with a markedly increased risk of premature death for all causes, specifically cardiovascular disease. The cutoff point above which there was a marked survival benefit was $13 \text{ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ [3.7 metabolic equivalents (METs)] in women and $15\ \text{ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ (4.3 METs) in men [8]. In our study, the baseline peak VO_2 was $18.0\ \text{ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ and the results showed significant improvement in exercise capacity, which is in line with most of the studies using combination of aerobic and resistance training in both diabetic and non-diabetic participants ts [15-18,23]. Like other studies, the baseline exercise capacity was noted to be lower in diabetic participants. Evidence suggests that specific pathogenic mechanism such as poor glycemic control and myocardial dysfunction may have contributed to this phenomenon [28]. The increase in the peak VO_2 obtained from our study was very similar to the observational studies conducted over 1 year [15,23]. Moreover, epidemiological studies have indicated that for every 3.5 $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ (1 MET) increases in exercise capacity, there was a 13% decrease in all-cause mortality and 15% decrease in cardiovascular events implying the health benefits of cardiorespiratory fitness [13]. This further supports the outcome of our exercise intervention study which improved the exercise capacity by a mean of $3.0 \text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. Muscular strength and endurance are inversely associated with risk of death from all causes after controlling for potential confounders, including cardiorespiratory fitness [29]. In addition to greater strength, participation in resistance or strength exercise training may slow or even reverse the degeneration of bone mineral density in individuals with osteoporosis [8]. The muscular fitness assessments including total handgrip and half push-up showed significant improvement after the 12 weeks of exercise intervention. In our review, few articles assessed the effect of exercise on muscular strength and endurance, mostly showed significant improvement [18,24]. In addition, muscular fitness improves the ability to maintain functional independence in the elderly. Lastly, despite the lack of statistical significance in the tests for sit-up and flexibility, participants showed clinically meaningful improvement that is believed to reduce musculo-tendinous injuries and prevention of low back pain [8].

Glycemic control over the preceding 2 to 3 months is assessed by HbA1c level and it is a good long-term variable to reflect our exercise intervention for 12 weeks. In our study, HbA1c showed significant improvement with clear distinct in diabetic participants. HbA1c was significantly reduced in many exercise interventional studies involving T2DM patients [16,17,20,22,23,25] and was never used as a comparison variable in non-diabetic individuals. Each 1% concentration reduction in HbA1c in T2DM was associated with a 37% decrease in risk for microvascular complications and a 21% decrease in the risk of any end point or death related to diabetes [30]. Hence, our observed mean concentration reduction of 0.5% (Fig. 2-B) among the diabetic participants might be expected to produce 18.5% and 10.5% reduction risk for these complications, respectively. However, these risks reduction are derived from pharmacotherapy studies and does not take into account improvement in cardiorespiratory fitness. The significant improvement in cardiorespiratory fitness demonstrated in our study might further reduce the morbidity and mortality in diabetic participants.

The changes in total cholesterol, HDL-cholesterol, LDL-cholesterol, and triglycerides were not statistically significant. Most studies examining the effect of exercise on cardiovascular health have found either weakly positive changes in lipid profile or no changes at all. More favorable changes were observed in those with more pronounced dyslipidemia [19], and have been related to significant loss in body fat [19] where the exercise intervention was for 16 weeks and 6 months, respectively. This supports the non-significant results in our studies where the baseline lipid levels were within the optimal range except for triglycerides which was borderline high. Moreover, dietary composition is an important confounding factor to influence lipid concentration and these study participants' dietary habits were not observed closely. Similar results were observed in studies where the exercise intervention was conducted over 8 weeks [16,22] and 3 to 6 months [25], all in diabetic patients. Nevertheless, clinical trials have indicated that 1% reduction in blood cholesterol level yields approximately a 2% reduction in coronary heart disease rates [31] meanwhile our study showed overall 4% reduction in total cholesterol which implies that our exercising participants have reduced about 8% of their risk.

Abdominal obesity measured by waist circumference is a major risk factor for cardiovascular disease and T2DM. The significant reduction in waist circumference demonstrated in this study, by a mean of 2.2cm compares favorably with the results from previous trials [17-19,24]. These studies assessed the effect of either aerobic or resistance, or combination of both training programs in adults with or at risk of developing diabetes in which reduction in waist circumference ranging between 2.4 and 3.4 cm was observed after 12 to 24 weeks of exercise training. The reduction in waist circumference was accompanied by significant reduction in weight and body fat percentage. However, no significant changes were noted in lean body mass (muscle percentage). A longer duration of both aerobic and resistance exercise programs reaching up to 12 month have shown significant decrease of body fat percentage and significant increase in lean body mass [23], suggesting the need for longer exercise programs in order to achieve these outcome variables.

Our study showed significant reduction in diastolic BP by a mean of 2.6 mmHg meanwhile no significant changes were noted in systolic BP. A meta-analysis suggested that in most individuals whether hypertensive or normotensive, a reduction in diastolic blood pressure confer a lower risk of stroke and CAD [32]. However the difference in diastolic BP was not significant among the diabetic participants (Fig. 2-C). This finding is consistent with most observational studies that suggest exercise lowers BP in non-diabetic individuals but reduction in diastolic BP is less commonly seen in individuals with T2DM [28]. Moreover, significant reduction in both systolic and diastolic BP was observed mainly in studies conducted over 6 months to 1 year [23,25].

A low resting HR reflects good health condition, whereas higher values are related to high mortality risk. Studies suggest that exercise training produces higher resting vagal activity therefore accountable for lower resting HR [33]. Although our study showed 3% reduction in HR but this was not statistically significant. Moreover HR and BP are mainly dependent on pharmacological therapy than physical activity [23].

Interpretation of the study findings is limited by the lack of non-exercise or diet only control group. In addition, only one mode of exercise training program, was applied which is the combination of aerobic and exercise training; therefore, unable to determine the effect of either only aerobic or only resistance training. Furthermore, we attempted to control the information on medications and/or alteration in management and dietary habit. However, these factors were not monitored rigorously due to access of patients to several healthcare professionals including family physicians, treating primary care doctors, and endocrinologists. Muscular fitness and flexibility assessment may have been conducted by different fitness instructors consequently affecting the precision of the measurements. Additionally, the metabolic markers were not available in 12 out of the 58 participants used for comparison which might have contributed to the non-significant changes observed in the metabolic markers. Nevertheless, the generalizability of the study was enhanced with the population of diverse in age, sex, ethnicity and co-morbidities. Despite a population with many medical concerns, the exercise prescription was well tolerated and resulted in good exercise adherence.

4. CONCLUSION

The twelve weeks of supervised exercise training produced substantial improvements in health-related indicators, similar to the response observed in other studies of longer duration. These results demonstrate the appropriateness of this form of exercise training in the prevention and management of glycemic control and cardiovascular risk factors. With the rising epidemics of non-communicable diseases in Kuwait, physicians and health educators should emphasize on similar supervised training programs for the achievement of long-term health benefits. Specifically, these include reduction in central obesity and improved health-related physical fitness. Furthermore, there is an evidence suggesting that fitness and exercise programs offered in community settings increase physical activity level and physical fitness for participating adults and older adults [34-36].

COMPETING INTERESTS

All authors must disclose no financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=599&id=12&aid=5278