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CASE REPORT

Improvements in health parameters of a diabetic and hypertensive patient with only 40 minutes of exercise per week: a case study

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ABSTRACT

Purpose: The present study aimed to report the effects of 15 weeks of a minimal dose resistance training on blood glucose levels, blood pressure, heart rate, physical capacity, and quality of life of a 67 old woman with type 2 diabetes mellitus, cardiopathy and hypertension.

Method: The Patient was sedentary with a family history of heart failure and coronary artery disease. She suffered a heart attack in 2013 and was submitted to six cardiac catheterizations and one angioplasty between the 2015 and 2017. On April 2017, she was initially untrained in resistance training and was followed for 15 weeks with the performance of 31 resistance training sessions. Resistance training followed a minimal dose approach with 4 exercises performed with 2 sets to muscle failure, twice a week.

Results: After follow up, the Patient presented a reduction in blood glucose, systolic and diastolic blood pressure, and heart rate at rest. There were also improvements on body mass index, cardiorespiratory fitness and quality of life. These results were accompanied by a reduction in the amount of antihypertensive and anti-diabetic medications.

Conclusions: These results suggest that only 40 min of resistance training per week might help to improve general health and quality of life in a patient with hypertension and type 2 diabetes mellitus.

IMPLICATIONS FOR REHABILITATION

• Minimal dose resistance training improved health parameters in a diabetic and hypertensive patient.
• Resistance training promoted a reduction in the drugs used to control blood pressure and blood glucose levels.

Introduction

Non-communicable diseases are responsible for 41 million deaths each year, which is equivalent to 71% of all deaths in the world. Cardiovascular diseases and diabetes are responsible for a great part of these deaths [1]. Hypertension is the most prevalent cardiovascular disease in the general population, especially in the elderly [2]. Diabetes affected 422 million people in 2016, and its prevalence has been consistently increasing [1,3]. Hypertension and type 2 diabetes mellitus (T2DM) share some important risk factors, such as overweight/obesity, inadequate eating habits and sedentary lifestyle [4,5]. As a result, about 70% of diabetic patients suffer from hypertension and cardiovascular disease is the leading cause of death among them [6–9].

Non-pharmacological treatments related to lifestyle changes, such as, physical exercise are considered important strategies to manage both hypertension and T2DM [10]. Among the different modalities of physical exercise, resistance training appears as a promising non-pharmacological option [11–13] as it has been shown to reduce blood glucose levels, increase insulin sensitivity and decrease resting blood pressure [14–16].

Whilst many studies address the effects of resistance training on T2DM and hypertension separately [3,12], these diseases often occur simultaneously [6] and are usually accompanied by other clinical conditions that might be seen as limitations for exercise performance [7]. Although large studies are important for bringing general information; they might lose important clinical details; moreover, the exclusion criteria adopted in many studies (e.g., patients using more than one antihypertensive drug, patients with three or more risk factors for cardiovascular disease, and uncontrolled hypertension) might exclude patients presenting characteristics that are usually found in clinical practice [17,18]. Conversely, whilst case studies lose in generalization, they might provide important details for clinical practice, acting as instructive examples to professional who might encounter similar problems, bringing a better understanding of clinical treatments and outcomes [19–21].

The exercise guidelines usually suggest protocols of relatively large volumes [22,23]. The American College of Sports Medicine recommends resistance training for large muscle groups (8–10 exercises) involving one to three sets of 8–12 repetitions at 60–70% of 1-repetition maximum (1RM) on two or three nonconsecutive days per week for the elderly [22]. Physical Activity Guidelines for Americans, recommend for older adults and for adults with chronic health conditions at least two days a week...
activities that involve all the major muscle groups (one set of 8–12 repetitions per each exercise) is effective [23]. On the other hand, there has been a suggestion that minimal doses (~20 min per session) of resistance training (one set of 8–12 repetitions for 4 exercises) might be sufficient to improve general health, especially in the older individuals [24,25]. Based on this, the present study aimed to report the effects of 15 weeks of a minimal dose resistance training program on blood glucose levels, blood pressure, heart rate (HR), physical capacity and quality of life of an older woman with T2DM and hypertension.

Method

The patient

The Patient of this case is a 67-years old sedentary woman with hypertension and T2DM [4,26], with no previous experience with resistance training, nonsmoker and nonalcoholic. She has been diagnosed with T2DM for 5 years and with hypertension for 10 years, and has familiar history of heart failure and coronary artery disease. She had an acute myocardial infarction in 2013 and was submitted to six cardiac catheterization procedures and one angioplasty between 2015 and 2017.

In the initial interview, on April 2017, the patient reported dyspnea during daily activities, chest pain and lower body edema (swelling). After clinical evaluation by a cardiologist, the initial tests were performed, and the Patient, was submitted to 15 weeks of a resistance training intervention. The Patient had been receiving nutritional counseling since July 2015 and this was continued during the study. However, the dietary intake of Patient was not controlled.

The study protocol was carried out with the approval of the Federal University of Goias Ethics Committee (approval number: 1.641.089) and written informed consent was obtained from the participant. The patient was informed of the possible risks and the interruption criteria for training are those described according to American Diabetes Association [6] and Brazilian Guideline of Arterial Hypertension [27]. The patient received medical clearance to exercise under the purpose protocol, which was carefully designed and evaluated to provide a low risk intervention. All sessions were performed in a hospital setting and closely supervised by health professionals. The experiment was performed according to the Declaration of Helsinki.

Resistance training protocol

The Patient was oriented to perform at least two resistance training sessions per week (Monday, Wednesday or Friday), always between 8.00 and 10.00 a.m. The program followed a minimal dose approach [24] and the sessions were directly supervised by two qualified physical education professionals, as it has been shown to influence the results of an resistance training program [28,29]. The resistance training sessions were composed of four exercises (plantar flexion, leg press – that was later substituted by single leg squats –, lat pulldown and dumbbell incline bench press), with preference to multi-joint, in accordance to previous suggestions [30]. Two sets were performed for each exercise with 2 min of rest interval between sets. During the first four weeks, the participant performed 10–12 repetitions to volitional fatigue. At week five, the leg press exercise was substituted by single leg squat exercise and all exercises were performed with 6–8 repetitions to muscle failure (Figure 1), as defined by Steele et al. [31]. Loads were adjusted whenever necessary to maintain the target range of repetitions. Interval between sets were 2 min and the Patient was encouraged to maintain 2 s in each the concentric and eccentric phase, with no rest in the transition phases. Each session lasted approximately 20 min.

![Figure 1. Study design. SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; 2020: two seconds in each concentric and eccentric phase with no rest in the transition phases. *SBP, DBP, and HR were measured 10 min before and after each resistance training session. *Blood glucose was measure 10 min before and after 17 of the 31 resistance training sessions. †Insulin neutral protamine hagedorn was reduced from 30 u [at morning] and 24 u [at night] to 25 u [at morning] and 20 u [at night], respectively.](image-url)
**Anthropometric measurements**

Anthropometric assessment was performed at baseline and after the intervention period (Figure 1). Height and body mass were measured with a precision of 0.1 cm and 0.1 kg, respectively. Body mass index was calculated by dividing body mass by height squared (kg/m²) [32]. To avoid inter-examiner variability, all measurements were performed by the same examiner who was previously trained and experienced in the procedures.

**Cardiorespiratory fitness**

The Patient performed a maximal graded exercise testing to exhaustion on a motorized treadmill (Centurion 200, Micromed, 2000) to determine maximal oxygen uptake and maximal HR at baseline and after intervention period (Figure 1). Prior to the test, the metabolic system was calibrated according to the manufacturer’s instructions and the patient received a standard set of instructions explaining the test. HR was recorded using a HR-monitor (Polar® V800, OI, Finland). Respiration gas samples were measured breath-by-breath using a metabolic system (Metalyzer 3B, Cortex, Germany). A ramp protocol was used with the purpose of eliciting exhaustion in 8–10 min of incremental exercise [33]. During the exercise test, the patient was verbally encouraged to exercise for as long as possible.

**Blood pressure and HR analysis**

Blood pressure was measured immediately before and 10 min after the end of all resistance training sessions using an automated oscillometric sphygmomanometer (Omron HEM-705) [34] following previous recommendations [4]. The Patient rested seated for 10 min before each measure. During measures, the shoulder was flexed, and elbow extended at the level of the heart. HR was recorded before and after each resistance training session using a HR-monitor (Polar® V800, OI, Finland), while the participant was seated and breathing spontaneously (Figure 1).

**Blood glucose analysis**

Blood glucose was measured immediately before and 10 min after the end of resistance training sessions by a portable glycosometer (Accu-cheq, Roche, Spain). Each measure was performed immediately after blood pressure measurement. The glucose meter and the measurement tapes were not available in all training sessions. Thus, blood glucose was measured in 17 of the 31 sessions (Figure 1).

**Quality of life**

Quality of life was evaluated before and after the intervention period by the 36-Item Short Form Survey (SF-36) (Figure 1). SF-36 is a self-administered questionnaire comprising 36 questions grouped into eight domains: physical functioning, social functioning, role limitations related to physical problems, role limitations related to emotional problems, mental health, vitality, bodily pain and general health perception [35]. A score ranging from 0 (worst measured health) to 100 (best measured health) was assigned for each domain. SF-36 was translated into local language [36]. A trained investigator was present to answer any question during the application of the test.

**Medications**

At the beginning of the treatment the Patient used propratilnitrate 10 mg (emergency medication) up to 3x day, gliblencamide 5 mg/day, losartan 50 mg/2x day, amldipine besylate 5 mg/day, atenolol 50 mg/2x day, hydrochlorothiazide 25 mg/day, simvastatin 20 mg/day, metformin chloridate 500 mg/2x day, insulin neutral protamine hagedorn 30 u (at morning) and 24 u (at night), acetylsalicylic acid 100 mg/day and ranitidine chloridate 150 mg/2x day (Figure 1).

**Results**

The Patient lost 6.2 kg in body mass (–9.1%) between baseline (68.2 kg) and after 15 weeks (62.0 kg), resulting in a decrease in body mass index of 2.5 kg/m² (from 27.3–24.8 kg/m²) [32].

After 15 weeks of resistance training, the Patient increased training load by 25 kg (10–35 kg; +250%) and 12 kg (4–16 kg; +300%) for the lat pulldown pull and dumbbell inclined bench press, respectively. Leg press exercise was performed until week five, the training load increased 30 kg (10–40 kg; +300%). The squat exercise started with body weight at week 6, increased to additional 6 kg at week 9, and to 10 kg at last week. Plantar flexion exercise was performed with no external load throughout the intervention.

Before starting resistance training intervention, the Patient was assigned to perform a maximal graded exercise test, but the test was interrupted at 3.6 km/h due to severe cardiac arrhythmia, suggesting the risk of ischemia. After fifteen weeks of resistance training, the test was concluded without risk of ischemia, being interrupted due to peripheral fatigue at 6 km/h, after 8 min. The Patient reached maximal oxygen uptake of 16 ml/kg/min and maximal HR of 121 bpm.

Patient’s systolic and diastolic blood pressure before and after the first resistance training session were 182/90 mmHg and 155/85 mmHg, respectively. After the last resistance training session, systolic and diastolic blood pressure before and after training decreased 29.1% and 24.4% (129/68 mmHg), and 21.3% and 22.4% (122/66 mmHg), respectively. Figure 2(A) shows systolic and diastolic blood pressure behavior before and after each resistance training session. HR before and after the first resistance training session were 90 bpm and 82 bpm, respectively. Before and after last resistance training session, HR was 77 bpm and 83 bpm. Figure 2(B) shows HR behavior before and after each resistance training session.

Blood glucose before and after the second resistance training session were 145 mg/dL and 157 mg/dL, respectively. After the last session (31th) blood glucose decreased 40.7% (86 mg/dL) in relation to the second session (2nd). After resistance training, the blood glucose decreased 51.6% (76 mg/dL) in relation to the second session (2nd).

The score of the SF-36 increased 36.6% (59.6 vs 81.4). Table 1 shows Patient’s quality of life before and after intervention according to each SF-36 domains.

During the study period, the Patient reported episodes of hypoglycemia and hypotension, which lead to the revision of the medication at 12th week (insulin neutral protamine hagedorn from 30 u [at morning] and 25 u [at night] to 24 u [at morning] and 20 u [at night]) (Figure 1). At the end of the 15 weeks, the Patient stopped taking the following medicines: propratilnitratre 10 mg (emergency medication), gliblencamide 5 mg, amldipine besylate 5 mg, atenolol 50 mg. The doses of losartan decreased from 50 mg/2x day to 50 mg/day, metformin chloridate from 500 mg/2x day to 500 mg/day, ranitidine chloridate from...
The combination of exercise choice with the low number of sets lead to a program of short duration, which is in agreement with a minimal dose approach previously cited [24]. Although there are few studies in the literature that report the best cadence for different pathologies, we opted for controlling movement velocity in order to control quality of movement and to avoid cardiovascular stress, since previous studies showed that higher velocity resulted in higher blood pressure responses [50].

Another novelty of this study concerns the intensity of the resistance training. It is known that the decrease in peripheral resistance, as well as peripheral aerobic adaptations, increase glucose transporter 4 and that peroxisome proliferator-activated receptor gamma coactivator 1-alpha are directly related to exercise intensity [18,51]. Especially in older people, intensity has been shown to be of utmost important [52,53] and the blood pressure reduction in response to an exercise program is dependent on its intensity [17]. Based on this, we opted for controlling movement velocity in order to control quality of movement and to avoid cardiovascular stress, since previous studies showed that higher velocity resulted in higher blood pressure responses [50].

It is known that at ages 40–69 years, each 20-mmHg increase in systolic blood pressure or 10-mmHg increase in diastolic blood pressure was associated with more than a doubling in the death rates of stroke, ischemic heart disease, or other vascular death [37]. Furthermore, a reduction in blood glucose from 145 mg/dL to 86 mg/dL may reduce the risk of cardiovascular events. In this sense, the reduction of baseline glycemia of the Patient is clinically favorable to its diagnosis [6]. Other clinically relevant factors were the improvement in quality of life (36.6%) and cardiorespiratory fitness of the Patient. Prevalence of mental health problems, including depression, cognitive impairment and dementia in elderly with type 2 diabetes mellitus surpasses the values found in the general population [26]. Moreover, cardiorespiratory fitness improvement is associated with a lower risk of mortality from all causes of cardiovascular diseases [38].

Although it is generally recommended to perform at least 150 min of moderate-intensity physical activity per week for health promotion and management of cardiometabolic diseases [39,40], our study showed that only 40 min of intense resistance training was able to reduce blood pressure, blood glucose, increase functionality, improve of quality of life and promote a reduction in the required pharmacological treatment.

Considering the risk of cardiovascular events, we choose a short duration training, to avoid large increases in the rate:pressure product and minimize the risk of cardiovascular overload [2,4,41]. Training sections consisted of four multi-articular exercises, with two sets for each exercise, 2-min interval between sets and a velocity of 2 s in the eccentric phase and 2 s in the concentric phase. The choice of multi-articular exercises was based on evidence that multi-joint exercises are more efficient in improving general physical fitness, maximal oxygen uptake and muscular strength than single-joint exercises [42] and also on evidence that the addition of single joint exercises to a multi-joint exercise program brings no morphological or functional benefits [30,43,44]. The option to perform a reduced number of sets per week was based on previous studies showing that increasing the number of sets brings no additional functional benefits for the older [45–47]. The combination of exercise choice with the low number of sets lead to a program of short duration, which is in agreement with a minimal dose approach previously cited [24].

Although there are few studies in the literature that report the best cadence for different pathologies, we opted for controlling movement velocity, using two second in each movement phase. There is an interesting debate about the use of high velocity resistance training for the older [24,48] and, whilst we recognize the clinical value of high velocity contractions [49], we opted for a controlled movement velocity in order to control quality of movement and to avoid cardiovascular stress, since previous studies showed that higher velocity resulted in higher blood pressure responses [50].

Another novelty of this study concerns the intensity of the resistance training. It is known that the decrease in peripheral resistance, as well as peripheral aerobic adaptations, increase glucose transporter 4 and that peroxisome proliferator-activated receptor gamma coactivator 1-alpha are directly related to exercise intensity [18,51]. Especially in older people, intensity has been shown to be of utmost important [52,53] and the blood pressure reduction in response to an exercise program is dependent on its intensity [17]. Based on this, we opted for using higher intensity of efforts, progressing from volitional fatigue to momentary muscle failure, which means that the exercise was interrupted when the Patient was not able to perform a complete repetition [31]. To avoid the potential risks associated with high effort, we opted to work with a reduced number of repetitions (<8) since
this has been shown to decrease the cardiovascular stress [41,54,55].

The Patient had been taking medicines for controlling hypertension and T2DM for many years before the study and her records show a progression in both the quantity of medicines used and the dose of each medicine. However, during the course of the study the Patient reported several episodes of hypoglycemia and hypotension, which lead to the revision of the medicines used. At the end of the 15 weeks, the Patient stopped taking some of the initially prescribed medicines (propranolol 10 mg, gliblencamide 5 mg, amlodipine besylate 5 mg, atenolol 50 mg) and reduced the amount of others (losartan decreased from 50 mg/2x day to 50 mg/day, metformin chloridate from 500 mg/2x day to 500 mg/day, ranitidine chloridate from 150 mg/2x day to 150 mg/day and insulin neutral protamine hagedorn from 25 u to 20 u (at morning) and from 20 u to 15 u (at night). This is in line with the suggestion that physical exercise might be an efficient adjunct in the treatment of several diseases, like T2DM and hypertension [10,40], acting as polypill [56]. It is important to note that a reduction of insulin neutral protamine hagedorn might not influence in body mass reduction [57]. Therefore, it is reasonable to assume that the decrease in medication might be occurred after the effects of resistance training on blood pressure and blood glucose.

In order to achieve the objectives of a resistance training programs, several variables need to be manipulated, such as load, number of repetitions, number of sets, movement velocity, exercises selection, rest interval between sets and rest interval between exercises. However, studies of these variables are usually confined to healthy people and there is no definition of which protocols would be safer for diseased populations [58]. Therefore, it is difficult to compare our results with previous reports. As far as we know, this is the first study to report a detailed rehabilitation program adjusting the resistance training variables in a Patient carrying many comorbidities and clinical conditions that are usually considered impeding for participating in an exercise program. The present case involved the work of a multidisciplinary group and highlights the use of a simple, ‘time-efficient’ resistance training program that can concomitantly treat pathologies such as hypertension and T2DM. Considering the high prevalence of these two diseases and that they are usually associated, it would be interesting to consider the inclusion of physical exercise interventions as a first line of treatment inside clinical settings, such as clinics and hospitals.

This case has two main limitations. Firstly, body composition was not assessed, and it could have provided information about Patient’s body fat and lean body fat improvements and helped explain some results. Another important limitation is the absence of rigid dietary control. Although the Patient had been receiving the same nutritional counseling for many years, we were not able to confirm if there were any changes in her dietary habits.

Conclusions
Fifteen weeks of a minimal dose resistance training program resulted in a reduction in body mass, blood pressure, blood glucose levels, HR at rest, and improved physical capacity and quality of life of a Patient with T2DM, cardiopathy and hypertension. In addition, the number and dosage of drugs was reduced. Taken together, these results suggest that resistance training helped to improve the Patient’s general health with only 40 min of exercise per week and should be used as a part of the treatment for Patients presenting multiple cardiometabolic diseases.

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No potential conflict of interest was reported by the authors.

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