Increasing Exercise Capacity in Patients With Hypertension - A Dual Perspective: Interval Training *vs.* Continuous Training

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Abstract

High blood pressure is a global health challenge because of its high prevalence and main risk factor for death. The aim of the present study was to determine the effectiveness of interval and continuous cycle ergometer training programs to improve health. The research was carried out on a sample of 20 patients, with the main diagnosis of grade 3 hypertension, male, aged 55 - 75 years old. Parameters aimed at analysing exercise capacity were: blood pressure, heart rate and SpO_2. The recovery programme consisted of endurance training on the cycle ergometer and medical gymnastics exercises. Research results. In this study both types of training led to significant increases in exercise capacity and improvements in blood pressure values, but interval training on the cycle ergometer led to decreases in systolic blood pressure values by 7.6 mmHg and diastolic blood pressure by 1.9 mmHg, compared to continuous training where decreases of only 4.7 mmHg in systolic blood pressure and 1.4 mmHg in diastolic blood pressure were recorded. Improvements were also found in the other parameters analysed, with the mention that the results were superior when interval training was used.

Keywords: *cardiac rehabilitation, high blood pressure, physical exercise, ergometer bike.*

1. Introduction and literature review

In 2021, cardiovascular disease has accounted for the main mortality cause worldwide, namely at least a third of all the deaths across the Globe

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and around 50% of all deaths in Europe. World Health Organisation predicts an increase of the figures in the next ten years.

Cardiac rehabilitation comprises long-term comprehensive programs that include medical evaluation, physical activity, modification of risk factors, education and recommendations by specialist physicians. The purpose of these programs is to limit the physiological and psychological effects of cardiac disease, reduce mortality, control cardiac symptoms, stabilise or regress atherosclerosis and improve the psychosocial and vocational status of patients (Aursulesei, Mitu & Alexa, 2015). This definition shows the fundamental role of physical exercise in the global recovery program applied to cardiovascular patients in general (hypertensive patients in particular).

Cardiovascular recovery presents a set of procedures designed to mitigate the cardiovascular risk factors and limit or stop disease progression. The beneficial effects of including physical exercises in the recovery programs for patients suffering from high blood pressure (HBP) are proven by the increase in the cardiovascular functional capacity, in the quality of life, in the improvement of the psychological condition and mortality reduction, implicitly.

Physical therapy, through physical exercise, contributes fundamentally to the patient's health state improvement through an increase in the exercise capacity and an improvement in the functional state. It is relevant to note that the elaboration of programs should consider both the individual characteristics of the patient and the evolution stage of the disease.

The programs of exercises for patients with cardiovascular pathology include, usually, a continuous low- or moderate-intensity aerobic routine; it is worth noting that the main benefits are represented by an increase in the maximum oxygen volume (Mezzani et al., 2013).

Studies have shown that the continuous aerobic training involves longer intervals with moderate intensity (60-80% of VO2max) **(**Rojhani-Shirazi et al., 2018**)** compared to high-intensity interval training, consisting of high-intensity, intermittent, short intervals (85–100% of VO2max) alternated with relative periods of rest (Villelabeitia-Jaureguizar et al., 2017).

Other studies demonstrate the direct relationship between the intensity of physical training and the cardio-protecting benefits of that training **(**Beckie et al., 2014).

In what concerns hypertensive patients, current research recommends for exercise intensity to be around 60% from the peak cardiac level on 12-13 on the Borg scale. Upper limits should not exceed the intensity of 85% of the peak cardiac rate on 15 – 16 on the Borg scale (Prescott, 2020).

Furthermore, high-intensity interval training determines an increase in the exercise capacity compared to moderate-intensity continuous training (Tamburús et al., 2015).

A recent study has noted more significant improvements of peak aerobic capacity after a high-intensity interval training compared to moderate-intensity continuous training (Mitchell et al., 2018). However, the debate concerning the optimal intensity of physical exercises among patients with HBP is still an open matter.

The importance of cardiovascular recovery in general and physical exercise in particular is highlighted by the conclusion that a reduction of systolic blood pressure by 10 mmHg may decrease mortality by 20 – 40%, while a reduction of diastolic blood pressure by 5 – 6 mmHg decreases the risk of myocardial infarction by 42% and the incidence of coronary disease by 15% **(**Campbell, Lackland & Lisheng, 2015).

The Treatment of Mild Hypertension Study (TOMHS) conducted by World Hypertension League in 1991 has demonstrated that a modification of the lifestyle, including weight loss and increase in exercise capacity contributes significantly to blood pressure control.

Recent research suggests that the aerobic exercises contribute to a modification of coronary risk factors. For instance, following an acute myocardial infarction, aerobic exercises favour a decrease in the body fat percentage (Kingwell & Jennings, 2015), reduce blood pressure (Bauman & Owen, 2014), lead to a reduction of triglyceride values and increase in the HDL cholesterol level (Ornish et al., 2018).

Pollock et al. (2000) have highlighted the relevance of physical training in the cardiovascular recovery among the hypertensive patients. They were

among the first who pointed out the introduction of resistance training, effective in the improvement in strength and muscle endurance.

Cardiac rehabilitation has a positive influence on clinical findings concerning the patients with cardiovascular disease, but it is worth mentioning that such exercises are underused in the case of women (Supervıa et al., 2017).

During cardiovascular rehabilitation, risk factors may be mitigated in both male and female patients. Scientific literature underlines significant differences between the results obtained for women compared to men. Hence, authors noted improved blood pressure values and higher cholesterol values in men compared to women. In addition, women record higher scores concerning depression and anxiety, at the end of the recovery program, compared to men (Hartel, 2018).

According to Grande et al. (2017), women experience higher mental stress and sometimes they have different expectations regarding the results of the treatment than men. Differences also persist concerning the satisfaction degree due to the implementation of the recovery program, both on the short and the long term, and the perceived benefits (Samayoa et al., 2014).

2. Materials and methods

The purpose of this study was to determine the capacity of interval and continuous training programs on the bicycle ergometer and improve health through the parameters studied and the identification of the most effective recovery methods between the two.

The study objectives concern the reduction of blood pressure values to a level minimising the cardiovascular risk of the disease, namely the enhancement of heart activity by reducing heart rate at rest and during effort, SO_2, even the exercise capacity.

The study comprised **20 male subjects (n=20)** randomly divided into two groups, the first performing **continuous training on the bicycle ergometer (n=10)** and **the second undergoing interval training on the bicycle ergometer (n=10).** The average age of the subjects was aprox. 64 years

old. The main inclusion criteria were the grade 3 high blood pressure diagnosis and male gender. Secondary inclusion criteria included sedentariness and being retired.

The GC group included patients with: overweight (10), type 2 diabetes (3), dyslipidemia (7). Furthermore, two of them suffered from scapulohumeral periarthritis and one suffered from vertigo.

The GI group included patients with: overweight (10), type 2 diabetes (4), dyslipidemia (9). Also, three of them suffered from epicondylitis and two suffered from cervical spondylosis.

Taken into perspective, we consider that the above mentioned diagnostics had little to no effect on the outcome of our study. Moreover, overweightness, type 2 diabetes and dyslipidemia closely linked with a number of cardiovascular diseases, including high blood pressure. Scapulohumeral periarthritis and epicondylitis are specific to elderly people (above 65 years old). The patient suffering from vertigo was kept in the study, even though his impairment led to him pausing several times during the training. In spite of this, he managed to finish the two week training, displaying good results.

All of them took anti-hypertensive medication and most of them, beta-blockers and diuretics. The duration of the recovery program was two weeks. The investigation took place from February to September 2022.

Within the study, we will use the bicycle ergometer Ergoline Ergoselect200, this being one of the most significant tools in the recovery of cardiovascular patients. It allows the appreciation and accurate measurement of cardiorespiratory parameters – blood pressure, heart rate, oxygen saturation and electrocardiogram.

The software used is ERS2, which:

- Allows group preparation in cardiac rehabilitation with up to 16 patients.
- Displays and stores in real time all ECG signals and training parameters BP, HR, SpO_2, MET.
- Allows the individualisation of cardiac rehabilitation practices, depending of the cardiac pathology of the patient and their adjustment

throughout training when detecting rhythm disorders and/or BP value increases.

Table 1. Characteristics of patients in the initial phase (the first training session during exercise)

CHARACTERISTICS	GC	GI
Age (years)	64.0 ± 3.62	64.2 ± 5.05
Gender	MALE	MALE
Body mass index (kg/m^2)	28.10 ± 1.63	28.03 ± 1.61
Smokers	2/10	3/10
Systolic blood pressure (mmHg)	146.2 ± 7.42	147.9 ± 3.78
Diastolic blood pressure (mmHg)	88.3 ± 4.97	90.4 ± 4.72
Heart rate (bpm)	91.3 ± 2.45	92.5 ± 3.89
Oxygen saturation (%)	96.5 ± 1.08	97.0 ± 1.05
Medication	**YES**	**YES**
Antihypertension treatment	10/10	10/10
Beta-blocker	10/10	8/10
Diuretics	9/10	9/10

Note: The values calculated are means ± standard deviation; GC – Continuous training group; GI – Interval training Group

3. Cardiac rehabilitation program

The cardiac recovery program was preceded by a specialty consult by the cardiologist involving both clinical and paraclinical investigations. They included anamnesis, EKG exam, echocardiography and blood works. The program took two weeks, in the gym, carried out under the supervision of a physical therapist. Every session took from 20 minutes initially, to 60 minutes (last sessions), in accordance to the rise of the effort capacity of every patient individually. The training sessions were comprised of medical gymnastics and endurance training on the bicycle ergometer. Gymnastics training consisted of warm-up, followed by joint mobility exercises, strength exercises, muscle endurance and stretching, followed by a period of cooldown.

Aerobic training used the bicycle ergometer and it included two different training ways: **high-intensity interval training** or moderate-intensity **continuous training**. Hence, we divided the subjects into two

groups: **the first group** performed **continuous training on the bicycle ergometer (n=10)** and **the second** performed **interval training on the bicycle ergometer (n=10).**

Continuous training was preceded by a 2 – 4-minute warm-up, the training per se was performed at an intensity between **25W – 50W**, followed by a 2 – 4-minute cooldown. The total duration of a training session was between 10 - 30 minutes (it grew in time in accordance with the patient's effort capacity). The training was individualised in real time; the intensity increase was dictated by blood pressure values, heart rate and SpO_2.

Interval training consists of the execution of 6 rounds of 2 – 4 minutes of effort at an intensity of **25W,** alternating with 5 rounds of 2 – 4 minutes of effort at an intensity of **35W** (first sessions) - **75W** (last sessions). Again, wattage was dictated by the effort capacity. The physical effort per se was preceded by a warm-up of 2 – 5 minutes and followed by a cooldown of 2 - 4 minutes. The total duration of a training session is 15 - 30 minutes. As in the case of continuous training, it was individualised in real time, the increase in intensity was dictated by blood pressure values, heart rate and SpO_2.

In the case of both groups, subjects were instructed to pedal at a frequency of 54 – 64 pedal beats/minute, throughout the training. Similarly, in the case of all the patients, both training intensity and duration were increased, in general, in comparison with the previous session.

The results below represent means of the BP, HR and SpO_2 measured constantly throughout the entire training using the ERS2 software program.

4. Results

Table 2. Continuous training results

Sub-jects	Blood Pressure						Heart Rate			Oxygen Saturation		
	SBP initial	DBP final	%	DBP initial	DBP final	%	HR initial	HR final	%	SpO_2 initial	SpO_2 final	%
1	142	136	-4.23%	87	85	-2.30%	94	96	2.13%	96	97	1.04%
2	137	133	-2.92%	83	82	-1.20%	89	92	3.37%	97	97	0.00%
3	145	141	-2.76%	93	91	-2.15%	95	98	3.16%	98	98	0.00%
4	138	133	-3.62%	87	85	-2.30%	91	94	3.30%	97	98	1.03%

Sub-jects	Blood Pressure						Heart Rate			Oxygen Saturation		
	SBP initial	DBP final	%	DBP initial	DBP final	%	HR initial	HR final	%	SpO_2 initial	SpO_2 final	%
5	152	146	-3.95%	97	94	-3.09%	89	91	2.25%	96	97	1.04%
6	158	150	-5.06%	95	95	0.00%	93	97	4.30%	97	96	-1.03%
7	148	145	-2.03%	84	83	-1.19%	92	95	3.26%	95	96	1.05%
8	156	150	-3.85%	85	85	0.00%	89	92	3.37%	98	98	0.00%
9	147	144	-2.04%	88	86	-2.27%	93	100	7.53%	95	97	2.11%
10	139	137	-1.44%	84	83	-1.19%	88	89	1.14%	96	96	0.00%
	Mean change		**-3.19%**	**Mean change**		**-1.57%**	**Mean change**		**3.38%**	**Mean change**		**0.52%**

Table 3. Interval training results

Sub-jects	Blood Pressure						Heart Rate			Oxygen Saturation		
	SBP initial	DBP final	%	DBP initial	DBP final	%	HR initial	HR final	%	SpO_2 initial	SpO_2 final	%
1	148	141	-4.73%	96	94	-2.08%	89	93	4.49%	97	98	1.03%
2	145	138	-4.83%	83	80	-3.61%	95	99	4.21%	98	99	1.02%
3	152	142	-6.58%	92	91	-1.09%	92	95	3.26%	96	98	2.08%
4	142	134	-5.63%	84	84	0.00%	94	96	2.13%	97	98	1.03%
5	150	135	-10 %	94	91	-3.19%	99	102	3.03%	98	99	1.02%
6	154	150	-2.60%	95	92	-3.16%	89	94	5.62%	98	98	0.00%
7	149	141	-5.37%	89	87	-2.25%	87	91	4.60%	96	97	1.04%
8	143	141	-1.40%	87	87	0.00%	96	99	3.13%	95	97	2.11%
9	147	139	-5.44%	95	93	-2.11%	95	97	2.11%	97	98	1.03%
10	149	142	-4.70%	89	86	-3.37%	89	94	5.62%	98	98	0.00%
	Mean change		**-5.13%**	**Mean change**		**-2.09%**	**Mean change**		**3.82%**	**Mean change**		**1.04%**

5. Interpretation of the results

On a general note, the cardiovascular recovery program, the aetiology of conditions and the medication were similar for both groups. The total number of patients included in the study was 20, wand they were distributed randomly into two groups (GC=10 and GI=10). We extracted the results obtained by comparing the values measured in the first and the last training session.

The participants of both training groups (continuous and interval) recorded improvements concerning systolic and diastolic blood pressure after two weeks of training.

The GC and GI groups improved their systolic blood pressure in average by 3.19% and 5.13%. It translated into better systolic blood pressure by 4,7 mmHg on average for the group with continuous training compared an improvement by 7,6 mmHg for the group with interval training.

Concerning diastolic blood, the GC group recorded a 1.57% improvement on average, while the GI group recorded an average improvement by 2.09%. In other words, for the GC group, diastolic blood pressure lowered by 1.4 mmHg on average, while in the GI group, it decreased by an average of 1.9 mmHg.

Following the two weeks of training, heart rate increased for both groups. More precisely, the heart rate of the GC group increased by 3.38% (on average), namely 3.1 beats/minute. The analysis of the results of the GI group has shown a reduction by 3.82% (on average), accounting for 3.5 beats/minute.

SpO_2 measurements have not highlighted significant modifications of this parameter in any of the two groups. On average, increases of 0.52% were recorded for the GC group, while an increase of 1.04% can be highlighted in the case of the GI group.

6. Discussions

The purpose of this study was to analyse, using the BP, HR and SpO_2 parameters, two types of training specific to cardiac rehabilitation, namely: continuous training and interval training. The results obtained after the two weeks of training have highlighted a significant improvement in the health state of subjects by enhancing the parameters mentioned above.

Hence, both types of training have shown beneficial effects on blood pressure and SpO_2. In the case of the latter, unlike other studies (Sorace et al., 2008; Spencer, 2007; Weston et al., 2014), we have not highlighted significant improvements in the parameter, which is due to it's high values recorded in all the subjects, at the beginning of our study.

The heart rhythm of subjects who performed continuous training increased, on average, by 3.1 beats/ minute. The group performing interval

training recorded average increases of 3.5 beats/ minute. Our conclusions are supported by Trachsel et al. (2020) and Reer et al. (2021).

Regarding the adverse effects of the two types of training, scientific literature has failed to report the emergence of major incidents related to their enforcement. Hannan et al. (2018) investigated the topic and has shown a small number of such events. Most of them had musculoskeletal and digestive impairments. Both training methods entail a very low cardiovascular risk. (Rognmo et al., 2018)

Concerning the equipment used, most studies used the treadmill, followed by the bicycle ergometer, or a combination of stepper, treadmill and bicycle ergometer. It sets a reliable foundation for choosing the bicycle ergometer as a training and recovery method (Biddle S.J., Batterham A.M., 2015).

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