Effect of a virtual cardiac rehabilitation program on patients with hypertension: A randomized trial

Efeito de um programa de reabilitação cardíaca virtual em pacientes com hipertensão: um ensaio randomizado

Luana Aparecida Brandão Leandro
Gabriella Cruz Ramos de Araújo
João Paulo Prado
Tarcísio Nema de Aquino
Juscelio Pereira da Silva
Giovane Galdino*

Universidade Federal de Alfenas (UNIFAL-MG), Alfenas, MG, Brazil

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*** Correspondence:** giovanegsouza@yahoo.com.br

Abstract

Introduction: Hypertension is among the main primary factors for the cause of death from cardiovascular diseases. Among the treatments for hypertension, physical exercise has stood out. However, the adherence of patients with hypertension to the practice of physical exercises is low, and thus strategies such as virtual rehabilitation may be beneficial, in addition to increasing adherence. **Objective:** This study aimed to evaluate the effect of a virtual cardiovascular rehabilitation (VCR) program on arterial blood pressure, physical conditioning and the quality of life of patients with hypertension. **Methods:** This is a randomized clinical trial with 59 patients with hypertension, divided into three groups: conventional cardiac rehabilitation (CCR), VCR and control (CO). Before and after the intervention period the patients were submitted to anthropometric data (BMI, body mass index), vital data (SBP, systolic blood pressure; DBP, diastolic blood pressure), quality of life (SF-36 questionnaire), respiratory muscle strength (MIP, maximum inspiratory pressure; MEP, maximum expiratory pressure) and functional capacity (6-MWT, six-minute walk test) assessment. Both VCR and CCR groups underwent aerobic training. **Results:** VCR protocol increased functional capacity ($p < 0.001$), expiratory muscle strength ($p < 0.002$), and quality of life in the domains in relation to limitation of physical ($p < 0.018$), emotional aspects ($p < 0.019$), social aspects ($p < 0.042$), and mental health ($p < 0.002$) when baseline and post-intervention were compared. **Conclusion:** The VCR program is an effective treatment strategy for improving the physical capacity and quality of life of patients with hypertension.

Keywords: Arterial hypertension. Cardiac rehabilitation. Physical exercise. Quality of life.

Resumo

Introdução: *A hipertensão está entre os principais fatores primários para a causa de morte por doenças cardiovasculares. Dentre os tratamentos para hipertensão, o exercício físico tem se destacado. No entanto a adesão dos hipertensos à prática de exercícios físicos é baixa e, assim, estratégias como a reabilitação virtual podem ser benéficas, além de aumentarem a adesão.* ***Objetivo:*** *Este estudo teve como objetivo avaliar o efeito de um programa de reabilitação cardiovascular virtual (RCV) sobre os níveis de pressão arterial, condicionamento físico e qualidade de vida de pacientes com hipertensão.* ***Métodos:*** *Trata-se de um ensaio clínico randomizado com 59 pacientes hipertensos, divididos em três grupos: reabilitação cardíaca convencional (RCC), RCV e controle (CO). Antes e após o período de intervenção os pacientes foram submetidos à avaliação de dados antropométricos (IMC, índice de massa corporal), dados vitais (PAS, pressão arterial sistólica; PAD, pressão arterial diastólica), qualidade de vida (questionário SF-36), força muscular respiratória (PImáx, pressão inspiratória máxima; PEmáx, pressão expiratória máxima) e capacidade funcional (TC6, teste de caminhada de seis minutos). Ambos os grupos RCV e RCC foram submetidos a treinamento aeróbio.* ***Resultados:*** *O protocolo de RCV aumentou a capacidade funcional ($p < 0,001$), a força muscular expiratória ($p < 0,002$) e a qualidade de vida em relação aos domínios limitação por aspectos físicos ($p < 0,018$) e emocionais ($p < 0,019$), aspectos sociais ($p < 0,042$) e saúde mental ($p < 0,002$) quando os valores basais e pós-intervenção foram comparados.* ***Conclusão:*** *O programa de RCV é uma estratégia de tratamento eficaz para melhorar a capacidade física e a qualidade de vida de pacientes com hipertensão.*

Palavras-chave: *Hipertensão arterial. Reabilitação cardíaca. Exercício físico. Qualidade de via.*

Introduction

Hypertension is a multifactorial clinical condition characterized by sustained high arterial blood pressure levels.[1] Studies have shown that hypertension may increase from 594 million adults in 1975 to 1.56 billion adults in 2025, mainly in developing countries.[2] In addition, there are several complications arising from hypertension (e.g., acute myocardial infarction, stroke, and kidney failure), which are among the main causes of morbidity and mortality, with significant consequences for public health.[3] Thus, the control of hypertension is an important step both to prevent and to reduce these complications.[3]

Among the various treatments for hypertension, non-pharmacological treatment has become important, mainly because it facilitates hemodynamic and autonomic adjustments, which help in controlling arterial blood pressure and, consequently, the quality of life of patients.[4] Thus, physical exercise has been an effective strategy because it produces a series of physiological responses (e.g., reduced sympathetic autonomic system activity and reduced peripheral vascular resistance), and it has proven to be important when associated with conventional pharmacological treatment.[4]

According to the World Health Organization, cardiac rehabilitation (CR) "is defined as the sum of activities required to favorably influence the underlying cause of the disease and to provide the best possible physical, mental, and social conditions, so that the patients may, by their own efforts, preserve or resume, as normally as possible, a place in the community".[5] Typically, patients in CR programs are supervised during established exercises in order to improve functional capacity and reduce cardiovascular risk factors.[6] One of the mechanisms involved in the reduction of cardiovascular risks by exercise is the reduction of hypertension.[7,8] This effect is found both in the treatment and control of this pathology by exercise. Physical training can reduce systolic and diastolic blood pressure levels by up to 11 and 8 mmHg, respectively.[9] In 1984, a study conducted by Blair et al.[10] had already shown that physically active individuals are 1.52 less likely to develop hypertension.

In addition, many types of physical training have emerged to complement resources aimed at improving fitness and physical rehabilitation. Virtual rehabilitation (VR) is one of these modalities. VR started to be used as a tool in motor rehabilitation at the end of the 20th century, and today it is used in several types of treatments for different pathologies that involve motor rehabilitation.[11] VR provides a unique medium suited to satisfy several requirements for effective rehabilitation intervention.[11] Furthermore, it can create a totally virtual and three-dimensional environment, where the patient interacts through visual, tactile, auditory, and sensory stimuli, recreating as much of the reality as possible, and facilitating the improvement of gait, balance, motor coordination, and physical capacity, among

other aspects.[12-14] Although the use of virtual reality in various forms of rehabilitation is remarkably effective, few studies have investigated this treatment strategy in patients with heart disease. Thus, the aim of this study was to verify the effect that a virtual cardiovascular rehabilitation (VCR) program has on the arterial blood pressure, physical conditioning, and quality of life of patients with hypertension.

Methods

This was a randomized clinical trial with hypertensive subjects, and it was registered in the Registration Platform of Clinical Trials. The study was approved by the local Ethics Research Committee (CAAE: 40764014.8.0000.5414) and conducted in accordance with the Declaration of Helsinki and the CONSORT recommendations for non-pharmacological trials.[15]

Participants who had been waiting for physiotherapeutic treatment at a local public health system and who fulfilled the following criteria were included: diagnosis of controlled hypertension with a medical referral form for physiotherapeutic treatment provided by the local public health system; any race or gender; no history of orthopedic, neurological, or psychological disorders; aged 30 or older; and had not performed physical activity in the previous three months. The exclusion criteria were as follows: grade III or grade IV heart failure; recent acute myocardial infarction; unstable angina; acute pericarditis; pulmonary hypertension; uncontrolled diabetes mellitus; patients who had three consecutive absences during the intervention; and pregnancy. Additionally, participants were excluded if they were unable to answer the quality of life questionnaire and fulfil the exercise protocols.

All participants (n = 85) with potential for eligibility were contacted by telephone, and those who were interested (n = 72) in participating were invited to attend a physical examination for inclusion and exclusion criterion. A physiotherapist, who was unaware of the treatment allocation, screened the people in order to confirm eligibility.

Eligible participants were informed about the study procedures. Those who agreed to participate in the study signed a consent form and were randomized, assessed, and allocated to three experimental groups, using a simple 1:1:1 computer-generated randomization ratio. The allocation was concealed by using consecutively sealed, numbered, opaque envelopes. Due to the characteristic of the treatment, which included physical exercise, neither the therapist nor the participants could be blinded. The groups in which the participants were randomized were the following: control (CO, n = 23), patients with hypertension that did not perform any type of physical activity; CCR (n = 25), patients with hypertension undergoing conventional cardiac rehabilitation; VCR (n = 24), patients with hypertension undergoing virtual cardiac rehabilitation.

The primary outcomes evaluated were arterial blood pressure, functional capacity, and quality of live; the secondary outcomes were heart rate, maximum inspiratory pressure (MIP), maximum expiratory pressure (MEP), and body mass index (BMI). The evaluation consisted of anamnesis and information about when the hypertension arose (history of the current and previous illness), symptoms, quality of life, pharmacotherapy use, level of physical activity, and type of occupation. Additionally, anthropometry, respiratory muscle strength, functional capacity, vital signs, and quality of life were evaluated, as described below.

Height and body mass were measured in order to calculate the BMI. Weight was measured using a portable stadiometer (Seca 217, CA, USA), in which the barefoot subjects were positioned upright, with arms hanging beside the body, and the heels, back, and head touching the wooden column. Body weight was measured in kilograms on a platform scale (Filizola, São Paulo, Brazil), 200 kg capacity and accurate to 100 g, placed on a flat surface and calibrated for each weighing. BMI was evaluated according to the reference values previously described in the literature.[16,17]

For measurements of diastolic blood pressure (DBP) and systolic blood pressure (SBP), participants were seated at rest for 10 min, and the mid-upper arm circumference was evaluated using a calibrated aneroid sphygmomanometer coupled to an appropriately sized brachial blood pressure cuff placed on the arm. All measurements were made on the left arm at the level of the heart. The average of two readings was recorded as the blood pressure value for the individual. Standard recommended procedures were used for the selection of the position and size of the sphygmomanometers used.[18]

Measurements of MIP and MEP, which are indicators of respiratory muscle strength, were taken while the individual was seated, using an analogic

manovacuometer (Wika, SP, Brazil) with a range of -120 to +120 cmH_2O in a scale intervals of 4 cmH_2O, with a silicone adapter for manual maneuvering and a mouthpiece with an orifice at the distal end that was sealed during inhaling, thereby facilitating the exact time to be measured.[19]

For evaluation of physical capacity, we used the six-minute walking test (6-MWT) in accordance with the guidelines of the American Thoracic Society.[20] The test was conducted on a 30-meter indoor walkway, whose length was marked every 5 m with non-slip-colored tape glued to the floor. Before and immediately after the test, heart rate (HR), SBP, DBP, and rating of perceived exertion scores of each subject were measured and recorded. Using a wristwatch, the resting HR was measured for 60 seconds, by palpation at the radial artery. This measurement was preceded by at least 5 minutes of seated rest.

The quality of life was evaluated via the SF-36 (Short Form Health Survey) questionnaire, which consisted of 36 items, in which all but one of the items were assigned to one of the eight health domains covering various aspects of physical and mental health: physical functioning (10 items), physical role functioning (4 items), bodily pain (2 items), general health perceptions (5 items), vitality, (5 items), social role functioning (2 items), emotional role functioning (3 items), and mental health (5 items).[21] The highest scores in each domain represent better health status, with scores ranging from 0 to 100: the closest to 0, the least favorable to health status, and the closest to 100, the most favorable one. During the administration of the questionnaire, the questions were read and clarified by the evaluator and answered by the participants. The administration of the entire questionnaire, as well as the scoring, was done using the SF36+ app.

All measurements previously described were taken between 7:30 and 10:00 AM, with the participants instructed to avoid coffee, alcohol, nicotine, and exercise for at least two hours before the assessment. After baseline assessments, participants of VCR and CCR groups started training, and on the two days after the last session a new assessment was carried. In the CO group, reevaluation was done similarly to the intervention groups. Blind investigators have taken all outcomes assessments to the interventions.

For interventions, CCR group participants performed three 50-minute sessions of aerobic exercise in treadmill (Movement RT250, Brazil) per week, on non-consecutive days, for 12 weeks, and a total of 36 sessions. VCR group performed two 70-minute sessions per week on non-consecutive days, for 15 weeks, and a total volume of 30 sessions. VCR´s sessions consisted of six supervised aerobic exercises: three for the upper limbs and three for the lower limbs, selected from the video games Nintendo Wii (Hula Hoop, Footing, and Rhythmic Boxeo) and Xbox 360 (Run the Word-Broadway, Wall Breaker, and Legs-100%). For CCR group, at the beginning, during every 10 minutes, and at the end of each session, SBP, DBP, HR, and the perceived exertion rating were checked. In the VCR group, these variables were measured before the session and after each of the six exercises. In the CO group, participants were instructed to perform only simple activities associated with daily living.

Both CCR and VCR groups exercised at 60 - 70% HR (target zone), calculated in accordance with the Karvonen formula,[22] and measured continuously with a portable HR monitor (Polar, NY, USA). The CCR group started the training program with 50 minutes of activity divided as follows: 5 minutes warm-up, 40 minutes of training in the target zone and final 5 minutes of cool down. While the VCR group performed the same period for warm-up and cool down, the training was maintained at 60 minutes. Both interventions were performed between 7:00 and 10:00 AM. After the study, patients in the CO group were invited to participate in the CR program.

For the present study, the sample size was calculated based on a previous study.[23] This study was chosen for the sample calculation, due to the similarity with the analyzed variables and the experimental protocols of the present study. The calculation was performed using the Gpower version 3.1.9.2 program, in which a significance level of 0.05, a power of 80%, and a correlation coefficient of 0.8 for all variables were adopted. Based on the means obtained in the aforementioned study, which found an aerobic training-induced decrease in SBP values (147.3 ± 6.9 mmHg) compared to control group control (155.4 ± 8.3 mmHg), the calculations were performed, which took into account the primary outcomes and demonstrated the need for an "n" of at least 14 individuals in each group. Considering the possibility of dropouts, we decided to increase the number of study participants in relation to the estimated sample size.

Statistical analysis

Analyses related to the effect of cardiac rehabilitation programs were performed in the per-protocol population. This population considers all eligible patients treated

and evaluated, which in the case of the interventions arms was defined as all patients who completed at least one VCR or CCR programs.

Descriptive statistics was used to report the sample characterization data, considering measures of central tendency and frequency of outcomes. Shapiro-Wilk test was used to assess the normality of the data. Numerical data normally distributed were presented as means and standard deviation. Non-parametric numerical data were presented as median and interquartile range. In turn, qualitative variables were presented through frequency distribution, with the percentage of occurrence of each variable in the investigated sample being reported.

To investigate the differences in clinical variable and quality of life between baseline and post-intervention, two-way ANOVA was used. For two-way ANOVA, the assumptions of normal distribution of the residues (graphic analysis) and homogeneity of variances (Levene test) were verified and respected for each outcome. For clinical variable and quality of life that showed statistical significance in the two-way ANOVA, followed by Bonferroni post hoc test. All analyzes were performed using the Statistical Package for the Social Sciences (SPSS) for Windows (Version 23.0), and the level of significance was set at 5%. Data analysis was performed by a blinded statistician.

Results

This study began with 72 participants. After randomization, 23 were allocated to the CO group, 25 to the CCR group, and 24 to the VCR group. During the study, 13 subjects did not complete, which was finished with 59 participants (20 in the CO group, 20 in the CCR group, and 19 in the VCR group) (Figure 1).

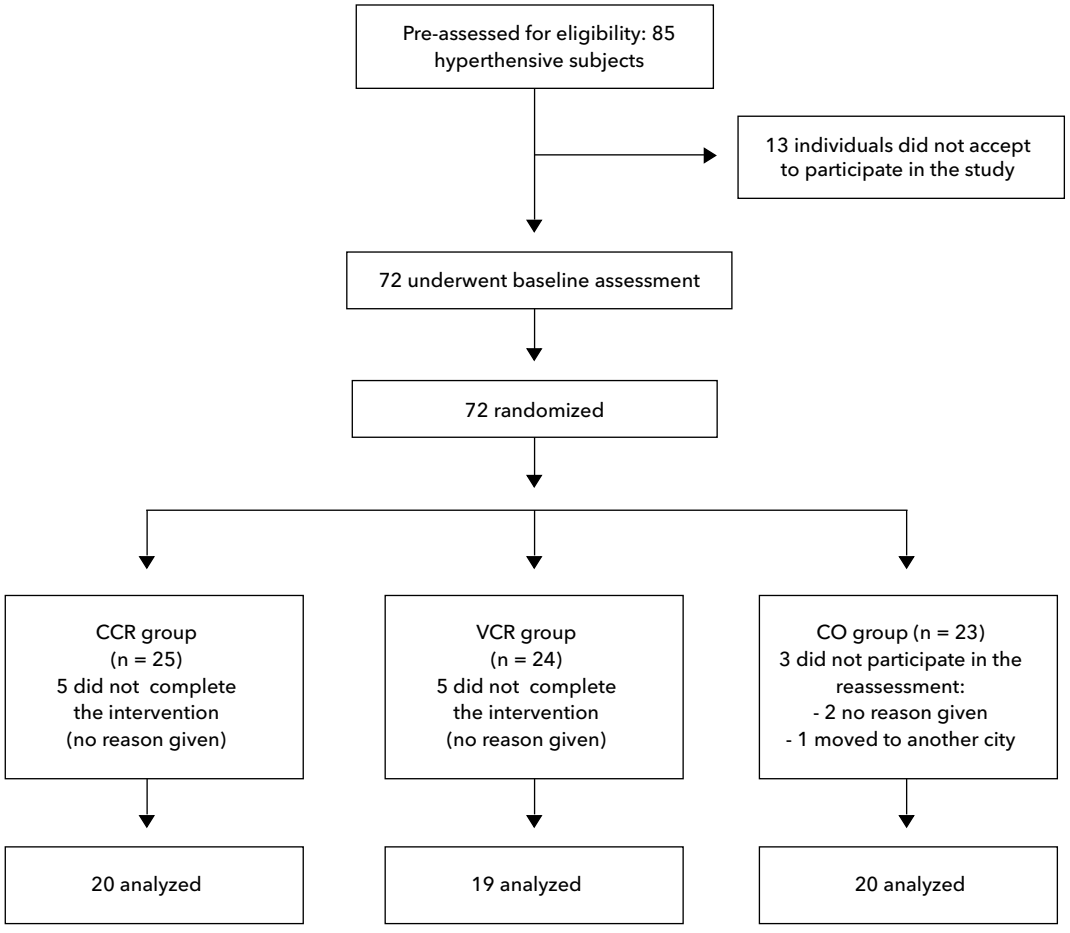

Figure 1 - Flowchart of recruitment.

Most participants of the study were women (73%), 60% composed the CO group, 65% the CCR group, and 94.7% the VCR group (Table 1). The average age of the participants was 65.8 + 2.4 years, which remained homogeneous in the three groups (VCR: 63.2 + 10.3; CCR: 67.9 + 6.4; CO: 66.5 + 8.3). In addition, the median values of the characterization of the total sample of the study demonstrate the presence of hypertension (140 x 80 mmHg), slight reduction in respiratory muscle strength (MIP: -100 cmH_2O, MEP: 91 cmH_2O) and good physical capacity (399.5 m walked in the 6-MWT) (Table 1). Median values for BMI (29.5 kg/m²) characterize the total sample as overweight.[16,17] Furthermore, HR values were controlled in the study participants (Table 1).

Table 1 - Characterization of participants of the study

Clinical variable	CO group (n = 20) Mean (SD) or Median (IR)	CCR group (n = 20) Mean (SD) or Median (IR)	VCR group (n = 19) Mean (SD) or Median (IR)	Total sample (n = 59) Mean (SD) or Median (IR)
Men (%)	40	35	5.3	27
Women (%)	60	65	94.7	73
Age (years)	66.5 ± 8.3	67.9 ± 6.4	63.2 ± 10.3	65.8 ± 2.4
PAS (mmHg)	140.0 (130 - 140)	130.0 (120 - 140)	140.0 (130 - 150)	140.00 (130 - 140)
PAD (mmHg)	80.0 (80 - 90)	80.0 (80 - 90)	80.0 (80 - 90)	80.0 (80 - 90)
HR (bpm)	72.4 ± 10.3	70.8 ± 11.3	77.7 ± 15.8	73.5 ± 12.8
6-MWT (m)	420.0 (390.0 - 470.0)	395.3 (315.2 - 556.6)	360 (300.0 - 420.0)	399.5 (315.7 - 464.0)
MIP (cmH_20)	-90.0 (-60.0 - -100.0)	-100.0 (-69.7 - -120.0)	-100.0 (-70.0 - -120.0)	-100.0 (-69.5 - -120.0)
MEP (cmH_20)	90.0 (80.0 - 120.0)	99.0 (105.0 - 120.0)	90.0 (86.0 - 120.0)	91.0 (-76.0 - 120.0)
BMI (kg/m²)	28.6 (29.9 - 32.0)	29.6 (25.7 - 31.7)	31.0 (26.8 - 32.8)	29.5 (26.3 - 32.0)

Note: CO group = control group; CCR group = conventional cardiac rehabilitation group; VCR group = virtual cardiac rehabilitation group; SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate; 6-MWT = six-minute walking teste; MIP = maximal inspiratory pressure; MEP = maximal expiratory pressure; BMI = body mass index. Data indicated as mean ± standard deviation (SD) or median and interquartile range (IR) or percentage (%).

Regarding clinical variable, the present study demonstrated a significant reduction ($p < 0.029$) of systolic blood pressure from baseline to post-intervention values in the CCR group, as demonstrated in Table 2 (moment baseline vs. post by ANOVA). In addition, MEP values increased significantly in both CCR ($p < 0.001$) and VCR ($p < 0.002$) groups when baseline and post-intervention were compared (Table 2). VCR group also presented a significant increase ($p < 0.001$) in the distance walked on the 6-MWT when baseline and post-intervention were compared (Table 2).

In addition to clinical variable, the Table 2 shows a significant improvement in quality of life domains limitation of physical aspects ($p < 0.003$), pain ($p < 0.013$), vitality ($p < 0.001$), social aspects ($p < 0.003$), limitation of emotional aspects ($p < 0.001$), and mental health ($p < 0.009$) in CCR group when baseline and post-intervention were compared (moment baseline vs. post by ANOVA). VCR group also significantly improved the limitation of physical aspects ($p < 0.001$), social aspects ($p < 0.003$) and limitation of emotional aspects ($p < 0.001$) domains when baseline and post-intervention were compared.

Interestingly, this study found a significant improvement in CO group in relation to limitation of physical aspects ($p < 0.001$) and limitation by emotional aspects domains ($p < 0.001$) when baseline and post-intervention were compared (Table 2).

Table 2 - Clinical variables and quality of life of study participants

Clinical Variables	CO group (n = 20) Mean (SD)		CCR group (n = 20) Mean (SD)		VCR group (n = 19) Mean (SD)		ANOVA		
	Baseline	Post	Baseline	Post	Baseline	Post	P group	P moment	P interaction
SBP (mmHg)	136.84 ±12.49	133.16 ±14.92	135.00 ±15.39	126.50† ±11.82	137.89 ±16.18	134.74 ±15.04	0.302	0.025*	0.554
DBP (mmHg)	84.21 ±8.37	85.74[a] ±10.73	82.50 ±7.86	76.00[a,b] ±9.94	84.74 ±10.73	84.74[b] ±14.28	0.047*	0.336	0.131
HR (bpm)	72.4 ±10.3	73.4 ±10.0	70.8 ±11.3	68.8 ±13.2	77.7 ±15.8	73.7 ±10.3	0.249	0.214	0.339
6-MWT (m)	423.05 ±60.37	408.21 ±65.25	436.77 ±128.55	432.67 ±105.01	357.23 ±99.86	455.20† ±110.77	0.614	0.007*	0.001*
MIP (cmH_20)	-87.37 ±25.78	-89.47 ±28.76	-90.60 ±31.41	-96.20 ±27.24	-94.11 ± 25.83	-95.00 ±2 4.75	0.714	0.383	0.827
MEP (cmH_20)	88.84 ±20.13	93.68 ±26.50	93.60 ±27.22	110.55† ±14.54	89.16 ±25.14	104.68† ±20.54	0.259	0.001*	0.150
BMI (kg/m^2)	30.15 ±6.36	30.17 ±6.91	29.26 ±3.47	27.85 ±2.59	30.37 ±3.76	30.29 ±4.07	0.411	0.344	0.401
FC	72.89 ±21.87	75.26 ±18.52	71.25 ±22.35	77.75 ±26.38	58.68 ±25.59	66.32 ±22.03	0.129	0.051	0.716
LPA	44.89 ±36.06	66.32† ±26.71	56.30 ±34.28	82.50† ±25.77	42.11 ±40.87	63.16† ±36.67	0.145	0.001*	0.892
Pain	40.7 ±22.8	46.4[a] ±24.7	57.1 ±26.0	73.5†[a] ±23.6	53.1 ±29.0	59.5 ±21.3	0.007*	0.014*	0.425
GH	58.6 ±20.2	56.32[a] ±20.71	66.4 ±17.6	77.25[a] ±18.64	61.3 ±22.2	63.32 ±24.06	0.046*	0.169	0.082
VIT	56.5 ±26.0	54.7[a] ±25.5	59.0 ±25.8	74.7†[a] ±17.5	54.4 ±26.9	62.6 ±25.0	0.027*	0.009*	0.037*
AS	73.74 ±23.72	74.74 ±28.33	61.25 ±32.65	79.40† ±24.15	72.64 ±29.67	84.92† ±21.48	0.542	0.003*	0.116
LAE	27.00 ±34.79	57.53† ±37.55	48.30 ±41.20	78.40† ±29.18	54.33 ±38.82	75.39† ±31.19	0.143	0.001*	0.684
MH	68.42 ±19.68	66.11 ±19.48	68.35 ±24.16	79.90† ±17.49	62.32 ±23.14	68.84 ±25.66	0.358	0.040*	0.080

Note: CO group = control group; CCR group = conventional cardiac rehabilitation group; VCR group = virtual cardiac rehabilitation group; SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate; 6-MWT = six-minute walking teste; MIP = maximal inspiratory pressure; MEP = maximal expiratory pressure; BMI = body mass index; SF-36 domains: FC = functional capacity; LPA = Limitation of physical aspects; GH = general health; VIT = vitality; SA = social aspects; LEA = limitation of emotional aspects; MH = mental health. Data indicated as mean ± standard deviation (SD) were compared using Two-Way ANOVA. *Significant p-values ($p < 0.05$) in two-way ANOVA. †Significant intra-groups differences ($p < 0.05$) in the post-hoc test. Significant between-groups differences in the post-hoc test: [a]CO group post vs CCR group post; [b]CCR group post vs VCR group post. No significant difference between groups were found in the post hoc test in the baseline comparisons.

Discussion

The current study showed that VCR was efficient in improving the quality of life of patients with hypertension, especially in relation to limitation of physical and emotional aspects, social aspects and mental health. In addition, this rehabilitation cardiac protocol improved the functional capacity and expiratory muscle strength when compared to baseline values. A reduction in SPB and DBP values found after CCR demonstrates that this protocol may be more efficient in controlling blood pressure and, consequently, the cardiovascular risk than VCR. In addition, a study found that a blood pressure reduction of 5/2 mm Hg reduced the first incidence of fatal and non-fatal stroke by 29%.[24] Although most studies have shown a reduction in arterial blood pressure after aerobic training, most of them were performed with young adults, unlike the present study that was conducted in hypertensive elderly with higher blood pressure levels.[25] Furthermore, studies have shown that greater the number of weekly sessions, greater the reduction in SBP and DPB levels.[26] Thus, we suggest that if the number of sessions was greater than three per week, we could find a reduction in SBP and DBP values in the VCR group.

Both VCR and CCR increased the quality of life of patients with hypertension in several domains evaluated. Another study had already shown an improvement in quality of life of subjects with cardiac disease after a CCR program of eight weeks composed of muscle strength training and 20-30 minutes of daily aerobic exercise.[27] However, this was the first study to find this effect by VCR, demonstrating that this protocol may be effective in improving the quality of life of hypertensive patients.

When evaluating physical capacity by 6-MWT, we found a significant improvement only in VCR compared to baseline values. The 6-MWT proved to be a reliable test for assessing functional capacity in a phase II/III CR population.[28] Despite the baseline levels found in the 6-MWT being very low in relation to the other groups, it was possible to verify the importance of the VCR in improving this parameter. This finding was verified by the interaction between group and time. Furthermore, in our study the improvement in functional capacity found by the VCR was similar to that found by the CCR in a study conducted by Bellet et al.[29]

Besides the results of the 6-MWT, our study showed that both VCR and CCR improved expiratory muscle strength (assessed by MEP) when compared to their baseline values. Although patients did not undergo respiratory muscle strength training, we suggest that the use of respiratory muscles, especially expiratory muscles, during aerobic exercise may be responsible for this finding. Another study showed that aerobic exercise increases respiratory muscle strength in patients with obstructive pulmonary disease.[30] Furthermore, a study evaluating male and female swimmers found that expiratory muscle strength was higher after the physical training, demonstrating that this parameter may be used as a marker of physical performance.[31] In addition, although our study did not correlate these data, a study found an improved expiratory muscle strength with reduction in the arterial blood pressure in hypertensive patients who underwent CCR for eight weeks.[32] Furthermore, a decrease in MEP was associated with a reduction in palmar strength (assessed by handgrip) in congestive heart failure patients.[33] Taken together, these findings demonstrate that the increase in expiratory muscle strength is directly associated with a healthy life condition, and this may be imposed by VCR.

Some limitations of this study must be considered. One of them concerns the frequency of weekly sessions for each group subjected to the exercise, which was not similar, but could certainly influence the physical performance. In addition, the baseline values of the 6-MWT in the control group were lower than in the other groups, although the comparison between groups found no differences.

Although CCR program is essential for hypertensive patients, statistics show that adherence is low. Studies have shown that 40-50% of patients who participate fail to complete the full program.[34,35] Thus, we believe that in addition to improving functional capacity, muscle expiratory strength and quality of life, virtual cardiac rehabilitation may produce motivational effects through interesting and fun tasks that can increase patient adherence.

Conclusion

The present study concludes that VCR may be an effective treatment strategy for patients with hypertension, mainly for improving quality of life and functional capacity. However, in relation to the control of arterial blood pressure no effect was found after this intervention, and more studies are necessary for this indication.

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Authors´contribution

GG supervised the research. Design and data collection were conducted by LBL and GCA. Tabulation, analysis and statistical interpretation of data by GG and JPS. LBL, GCA and GG were responsible for the writing of the manuscript and creation of tables and charts. GG and JPP, for the text preparation according to the journal´s guidelines. GG and JPS reviewed the manuscript, and all authors have approved the final version here published.

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