Home-based power training improves functional parameters and blood pressure after coronary artery bypass graft surgery: preliminary study

Treinamento de potência domiciliar melhora parâmetros funcionais e a pressão arterial após cirurgia de revascularização do miocárdio: estudo preliminar

Daniela Ribeiro Alves Flexa
ORCID: https://orcid.org/0000-0002-1438-5314
Programa de Pós-Graduação em Ciências da Saúde, Universidade Federal do Maranhão, Brasil
Departamento de Educação Física, Universidade Ceuma, Brasil
E-mail: danielaflexa@hotmail.com

Bruno Bavaresco Gambassi
ORCID: https://orcid.org/0000-0003-3852-0602
Programa de Pós-Graduação em Gestão de Programas e Serviços de Saúde, Universidade Ceuma, Brasil
Programa de Pós-Graduação em Educação Física, Universidade Federal do Maranhão, Brasil
E-mail: professorbrunobavaresco@gmail.com

Paulo Adriano Schwingel
ORCID: https://orcid.org/0000-0002-2935-3403
Programa de Pós-Graduação em Ciências da Saúde, Universidade de Pernambuco, Brasil
Programa de Pós-Graduação em Reabilitação e Desempenho Funcional, Universidade de Pernambuco, Brasil
E-mail: paulo.schwingel@upe.br

Luíz Filipe Costa Chaves
ORCID: https://orcid.org/0000-0001-8471-1843
Programa de Pós-Graduação em Educação Física, Universidade Federal do Maranhão, Brasil
E-mail: prof.filipecosta@gmail.com

Thiago Matheus da Silva Sousa
ORCID: https://orcid.org/0000-0002-9516-1215
Programa de Pós-Graduação em Educação Física, Universidade Federal do Maranhão, Brasil
E-mail: thiago_edfisica@outlook.com

Fabiano de Jesus Furtado Almeida
ORCID: https://orcid.org/0000-0002-3810-5014
Departamento de Educação Física, Universidade Ceuma, Brasil
Universidade Estadual do Maranhão, Brasil
E-mail: almeidafur@hotmail.com

Vinícius José da Silva Nina
ORCID: https://orcid.org/0000-0003-3017-7459
Programa de Pós-Graduação em Ciências da Saúde, Universidade Federal do Maranhão, Brasil
Hospital Universitário da Universidade Federal do Maranhão, Empresa Brasileira de Serviços Hospitalares, Brasil
E-mail: rvnina@terra.com.br
ABSTRACT

This study aimed to investigate the impact of remotely supervised home-muscle power training (RSHMPT) on physical function (PF), aerobic capacity (AC), autonomic cardiac control (ACC), and blood pressure (BP) in patients after coronary artery bypass grafting (CABG). The study sample consisted of 4 patients who underwent CABG. PF (dynamic balance, lower limb functional capacity, elbow flexion strength, handgrip strength), AC, ACC, and BP were evaluated before and after 8 weeks of RSHMPT. Experienced exercise physiologists administered the exercise protocol (8 weeks) virtually by WhatsApp® video calls. Remotely supervised RSHMPT consisted of multiarticular and monoarticular exercises performed by elastic bands. Clinical improvement has been demonstrated in dynamic balance ($d = 1.2$), lower limb functional capacity ($d = -0.8$), elbow flexion strength ($d = -1.0$), handgrip strength ($d = -0.8$), and systolic BP ($d = 1.2$), and AC ($d = -0.8$) after RSHMPT. These findings indicate that RSHRT promoted improvements in PF, AC, and systolic BP in the investigated sample.

Keywords: Cardiovascular surgical procedures; Muscle strength; Blood pressure; Heart rate; Exercise training.

RESUMO

Este estudo teve como objetivo investigar o impacto do treinamento de potência muscular em casa supervisionado remotamente (TPMCSR) sobre a função física (FF), capacidade aeróbia (CA), controle autonômico cardíaco (CAC) e pressão arterial (PA) em pacientes após cirurgia de revascularização do miocárdio (CRM). A amostra do estudo foi composta por 4 pacientes submetidos à CRM. FF (equilíbrio dinâmico, capacidade funcional de membros inferiores, força de flexão do cotovelo, força de preensão manual), CA, CAC e PA foram avaliados antes e após 8 semanas de TPMCSR. Fisiologistas do exercício experientes administraram o protocolo de exercícios (8 semanas) virtualmente por chamadas de vídeo do WhatsApp®. O TPMCSR consistiu em exercícios multiarticulares e monoarticulares realizados com faixas elásticas. A melhora clínica foi demonstrada no equilibrio dinâmico ($d = 1.2$), capacidade funcional dos membros inferiores ($d = -0.8$), força de flexão do cotovelo ($d = -1.0$), força de preensão manual ($d = -0.8$) e na PA sistólica ($d = 1.2$) e em AC ($d = -0.8$) após TPMCSR. Esses achados indicam que o TPMCSR promoveu melhoras na FP, CA e na PA sistólica na amostra investigada.

Palavras-chave: Procedimentos cirúrgicos cardiovasculares; Força muscular; Pressão arterial; Frequência cardíaca; Treinamento físico.

INTRODUCTION

Coronary artery bypass grafting (CABG) benefits individuals with coronary artery disease (CAD) (MERKOURIS et al., 2009; PAQUIN et al., 2020). According to a recent review study, CABG is the gold standard treatment for CAD (PAQUIN et al., 2020). These authors say that, besides secondary preventive surgery, pharmacological treatment is extremely important to attenuate the patients’ inflammatory and prothrombotic state. Evidence also shows that supervised physical rehabilitation improves respiratory muscle strength, aerobic capacity, quality of life, and hemodynamic and autonomic parameters in patients who had CABG (ALMEIDA et al., 2017; GAMBASSI et al., 2019a).
Despite such benefits, evidence indicates that treatment center rehabilitation adherence is still rather low (AREN A et al., 2012; THOMAS et al., 2019). Thus, home-based rehabilitation is an alternative for these patients (SMITH et al., 2011; OLGOYE; SAMADI; JAMALIAN, 2021).

Although benefits have been demonstrated in the said parameters after aerobic exercise as part of home-based rehabilitation, little is known about the effects of remotely supervised home-muscle power training (RSHMPT) with elastic bands in this population. Since this non-pharmacological strategy is easily accessible, inexpensive, and brings benefits (e.g., attenuating functional, hemodynamic, and autonomic losses), it is important to carry out research with this type of approach in post-CABG patients. Therefore, our objective was to investigate the impact of RSHMPT on physical function, aerobic capacity, autonomic cardiac control, and blood pressure in post-CABG patients.

MATERIALS AND METHODS

Experimental design and participants

This is an experimental study, with pre- and post-treatment tests designed for one group. Using a non-probabilistic sampling, we recruited patients from the cardiac rehabilitation program at the Department of Cardiac Surgery of the University Hospital of the Federal University of Maranhão (HU-UFMA), President Dutra Unit, São Luís, MA, Brazil. All patients signed an informed consent form after being properly instructed about the study proposal, the procedures they would have to undergo, and their potential risks and benefits.

The inclusion criteria were as follows: patients who have undergone a successful CABG (no complications during surgery and/or in the following weeks), with normal ejection fraction (> 50%), Class I according to the New York Heart Association, who participated in phases I and II of cardiac rehabilitation, not using any beta-blockers (e.g., atenolol), no impairments in the musculoskeletal system. Exclusion criteria were as follows: not being able to sign the digital informed consent form; with a history of smoking or regular alcohol consumption; with uncontrolled hypertension and/or diabetes mellitus. Also, participants were excluded for the following reasons: difficulty with the internet (n = 3); absences in assessments (n = 1); absences in the intervention (n = 1); difficulty in adaptation to the protocol (n = 2). Thus, the study sample consisted of 4 patients (Table 1).
Table 1. Baseline characteristics of the participants (n = 4)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characterization (mean ± standard deviation)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>67.7 ± 12.7</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>26.8 ± 3.3</td>
</tr>
<tr>
<td>Time of surgery (minutes)</td>
<td>262.3 ± 66.5</td>
</tr>
<tr>
<td>Time of hospitalization after surgery (days)</td>
<td>17.2 ± 6</td>
</tr>
<tr>
<td>Demographic (%)</td>
<td></td>
</tr>
<tr>
<td>Men (%)</td>
<td>75</td>
</tr>
<tr>
<td>Women (%)</td>
<td>25</td>
</tr>
<tr>
<td>Medications (%)</td>
<td></td>
</tr>
<tr>
<td>Diuretic</td>
<td>75</td>
</tr>
<tr>
<td>Angiotensin-converting-enzyme inhibitor</td>
<td>75</td>
</tr>
<tr>
<td>Statins</td>
<td>50</td>
</tr>
<tr>
<td>Associated comorbidities (%)</td>
<td></td>
</tr>
<tr>
<td>Systemic arterial hypertension</td>
<td>75</td>
</tr>
<tr>
<td>Type 2 diabetes mellitus</td>
<td>25</td>
</tr>
</tbody>
</table>

Font: Ribeiro et al. (2023).

Procedures

The experiments (in person) were performed in the Laboratory of Assessment and Physiology of Ceuma University. Experiments were separated into three distinct phases. In the first phase (in person), participants completed assessments of functional and cardiovascular parameters and aerobic capacity. Additionally, participants were submitted to familiarization with the proper technique of the physical exercises (intervention) utilized in the present study. In the second phase (remotely), experienced exercise physiologists administered the exercise protocols (8 weeks) virtually by WhatsApp® (WhatsApp LLC, Meta, Inc., Menlo Park, CA, United States of America [USA]) video calls. All participants spent one week getting acquainted with WhatsApp® (WhatsApp LLC, Meta, Inc.) video calls so they could handle them properly. In the third phase (in person), post-intervention, participants completed functional, cardiovascular, parameters, and aerobic capacity assessments.

Assessments

Physical function

The following evaluations were undertaken before and after 8 weeks of intervention: elbow flexion (30-seconds-arm curl); timed up and go test (TUGT) (dynamic balance); 30-second chair-stand test (30-s CST) (lower limb functional
capacity); and isometric handgrip (PODSIADLO; RICHARDSON, 1991; RIKLI; JONES, 2013).

**Aerobic capacity**

Patients have been submitted to a 2-minute stationary walk test before and after 8 weeks of intervention (PEDROSA; HOLANDA, 2009).

**Assessment of autonomic cardiac control by heart rate variability**

Participants remained in a supine position with 30º head elevation for 20 minutes to assess autonomic cardiac control. A Polar V800 heart rate monitor (Polar Electro Oy, Kempele, Finland) was used to continuously record beat-to-beat intervals (R–R intervals). At the end of the examination, the R–R intervals (RRi) were extracted in text format through the Kubios HRV Standard software for Windows (Kubios Oy, Kuopio, Finland, Release 3.1.0, 2018) to obtain the variables related to the frequency domain measurements of heart rate variability (HRV). The following variables were selected: mean of the sequence of the RRi (Mean RRi) and low frequency/high frequency (LF/HF) ratio.

**Blood pressure assessment**

Systolic blood pressure (SBP), and diastolic blood pressure (DBP) were measured between 8:00 and 11:00 am, according to the procedures detailed in the Brazilian Guidelines of Hypertension (BARROSO et al., 2021). Participants were instructed to refrain from exercising for 48 hours before the evaluation and from drinking caffeinated beverages and/or alcohol for 24 hours before the evaluation. An automatic, noninvasive, calibrated, and validated arterial blood pressure monitor (HEM-7200, Omron Healthcare Inc., Lake Forest, IL, USA) was used to measure SBP and DBP. Participants were instructed to remain silent. The cuff was placed on the arm about 2 centimeters above the antecubital fossa. Three blood pressure measurements were taken from both arms, with a 1-minute interval between them. The mean blood pressure values were used as office blood pressure.

**Intervention**

The training protocol was performed three times per week over 8 weeks with a minimum 48-hour rest interval provided between each exercise session. The RSHMPT
consisted of multiarticular and monoarticular exercises performed with Thera-Band® professional latex resistance bands (Thera-Band® Red, THERABAND, Akron, OH, USA) in chairs of appropriate height. Except for the squat on the chair exercise, all exercises were performed with a full range of motion, with concentric contractions performed as fast as possible, while the eccentric contractions were performed slowly within 3 seconds. Additionally, participants were instructed to avoid the Valsalva maneuver during the exercise.

Intervention intensity was monitored and controlled with the rate of perceived exertion (RPE) (DAY et al., 2004). The RPE was reported after the end of each set of exercises and, if the participant reported an RPE below the expectations [low intensity (easy; 2 points; scale of 1-10)], the tension of the elastic band was increased [moderate intensity (3 points; scale of 1-10)].

In the first two weeks, was performed familiarization with 2 sets of 6 repetitions (reps) (low intensity). In the main part, the exercise training volume was increased over the 8-week [1st – 2nd week (2 sets x 6 reps); 3rd – 4th week (2 sets x 8 reps); 5th – 6th week (2 sets x 10 reps); 7th – 8th week (3 sets x 8 reps) at moderate intensity.

The dynamic MPT protocol consisted of the following three combinations of two consecutive exercises, with no absolute rest intervals throughout the session (GAMBASSI et al., 2019b; BAVARESCO GAMBASSI et al., 2023). The protocol consisted of (i.e., 2 sets):

- vertical chest press interspersed with squat on the chair; vertical chest press interspersed with squat on the chair;
- hip flexion interspersed with squat on the chair; hip flexion interspersed with squat on the chair;
- seated row interspersed with squat on the chair; seated row interspersed with squat on the chair;
- hip abduction interspersed with squat on the chair; hip abduction interspersed with squat on the chair;
- elbow flexion interspersed with squat on the chair; elbow flexion interspersed with squat on the chair;
- plantar flexion interspersed with squat on the chair; plantar flexion interspersed with squat on the chair.
**Statistical analysis**

Statistical analysis was performed using Prism software (GraphPad Inc., San Diego, CA, USA, release 8.4.3, 2020). Continuous variables are presented as mean ± standard deviation after checking data normality using the Shapiro-Wilk test. The paired-sample *t*-test compared baseline (pre-training) with final (post-training) measurements. All measurements were two-tailed, and *p*-values were calculated with significance levels set at 5%. Cohen’s effect size (ES) *d* was calculated to determine the magnitude of the difference between the variables. An effect size between 0.20 and 0.49 was considered small, 0.50 and 0.79 moderate, and an effect size ≥ 0.80 was considered the largest magnitude of effect (COHEN, 1992).

**RESULTS**

Positive changes were found after 8 weeks of the RSHMPT with elastic bands for the following tests (Table 2): TUGT (*P* = 0.049) and isometric handgrip (left side; *P* = 0.045). Additionally, large ES was found in dynamic balance (*d* = 1.2), lower limb functional capacity (*d* = -0.8), elbow flexion strength (*d* = -1.0), handgrip strength (right side; *d* = -0.8), SBP (*d* = 1.2), and in aerobic capacity (*d* = -0.8).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Baseline</th>
<th>Post-intervention</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Functional parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbow flexion (repetitions)</td>
<td>18.8 ± 2.1</td>
<td>21.5 ± 3.8</td>
<td>Large</td>
</tr>
<tr>
<td>Timed up and go test (seconds)</td>
<td>9.1 ± 1.2</td>
<td>7.5 ± 1.6*</td>
<td>Large</td>
</tr>
<tr>
<td>30-s chair-stand test (repetitions)</td>
<td>15.8 ± 2.4</td>
<td>18.0 ± 3.2</td>
<td>Large</td>
</tr>
<tr>
<td>Isometric handgrip right (kg/f)</td>
<td>24.4 ± 5.1</td>
<td>29.9 ± 8.7</td>
<td>Large</td>
</tr>
<tr>
<td>Isometric handgrip left (kg/f)</td>
<td>22.7 ± 6.4</td>
<td>27.8 ± 9.2*</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Cardiovascular parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-minute stationary walk test (repetitions)</td>
<td>78.8 ± 11.2</td>
<td>91.3 ± 13.5</td>
<td>Large</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>115.3 ± 8.5</td>
<td>102.8 ± 12.7</td>
<td>Large</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>66.8 ± 9.2</td>
<td>61.5 ± 8.9</td>
<td>Moderate</td>
</tr>
<tr>
<td>Mean R–R intervals (milliseconds)</td>
<td>872.5 ± 29.7</td>
<td>906.3 ± 91.6</td>
<td>Moderate</td>
</tr>
<tr>
<td>LF/HF ratio</td>
<td>2.5 ± 3.5</td>
<td>1.5 ± 1.2</td>
<td>Small</td>
</tr>
</tbody>
</table>

Note: *significant difference (P < 0.05) between pre- (baseline) and post-intervention results.*

DISCUSSION

The main findings of the present study are the clinically improved physical function, aerobic capacity, and blood pressure in post-CABG patients submitted to remotely supervised home-based resistance training with elastic bands. This is demonstrated in the improved dynamic balance \((d = 1.2)\), lower limb functional capacity \((d = -0.8)\), elbow flexion strength \((d = -1.0)\), handgrip strength \((d = -0.8)\), SBP \((d = 1.2)\), and aerobic capacity \((d = -0.8)\).

To our knowledge, this is the first study to investigate the impact of RSHMPT on functional and cardiovascular parameters in post-CABG patients. The effects of home-based exercise have been widely investigated in different populations. In line with our findings, studies have demonstrated improved muscle strength in older people and increased power and mobility in patients with multiple sclerosis after home-based exercise (DeBOLT; McCUBBIN, 2004; KIS et al., 2019).

The present study has observed clinical effects on dynamic balance, lower limb functional capacity, elbow flexion strength, and handgrip strength in post-CABG patients submitted to RSHMPT with elastic bands. These findings have important public health implications since functional impairments are associated with depression and a higher risk of mortality (SASAKI; FUKUMOTO, 2022).

In addition to the functional benefits, we found an important reduction in SBP \((\Delta = -13 \text{ mmHg})\) and DBP \((\Delta = -5 \text{ mmHg})\) and clinical improvements in aerobic fitness \((d = -0.8)\). These findings are relevant, as improved blood pressure control is associated with a 9% reduction in the risk of mortality from CAD (WHELTON et al., 2002) – which is further reduced by lowering blood pressure and improving aerobic fitness (BLAIR et al., 1989; WHELTON et al., 2002).

A hypothesis to explain our findings is related to the characteristics of dynamic RSHMPT. This protocol does not include absolute rest intervals between sets and exercises. Thus, the cardiovascular and neuromuscular systems are simultaneously stimulated from the beginning to the end of the session. Exercises applied this way may have increased vasoactive substances to the point of reducing blood pressure. Corroborating this hypothesis, important reductions have been found in SBP \((\Delta = -16.5 \text{ mmHg}; \Delta = -9 \text{ mmHg})\) after practicing resistance training protocols like RSHMPT (GAMBASSI et al., 2016; GAMBASSI et al., 2019b). Further studies are needed to confirm our hypotheses.
Finally, this preliminary study has limitations such as sample size and lack of randomization. However, our findings may stimulate research on the topic to give health professionals more alternatives for post-CABG rehabilitation in settings other than treatment centers.

CONCLUSION

These findings indicate that RSHMPT with elastic bands promoted significant clinical changes in functional parameters, aerobic capacity, and systolic blood pressure in the investigated sample. As this is a preliminary study, it is imperative to conduct randomized controlled trials with more stringent control over the sources of invalidation, such as experimental studies involving randomized trials before and after treatment, and blinded investigators' assessments, to enhance the validity of the present findings.

ACKNOWLEDGEMENTS

The authors are grateful to all study participants and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES). This study was financed in part by the CAPES under Finance Code 001.

REFERENCES


