

## REVIEW ARTICLE

## Telerehabilitation for Cardiac Patients: Systematic Review

Danieli de Cristo,<sup>1</sup> Natan Pinto do Nascimento,<sup>1</sup> Alexandre Simões Dias,<sup>2</sup> Amanda Sachetti<sup>1</sup>

*Universidade de Passo Fundo (UPF),<sup>1</sup> Rio Grande do Sul, RS - Brazil*

*Hospital de Clínicas de Porto Alegre, Universidade Federal do Rio Grande do Sul,<sup>2</sup> Rio Grande do Sul, RS - Brazil*

### Abstract

Cardiovascular rehabilitation is one nonpharmacological intervention used to treat cardiovascular diseases. Despite the proven benefits of cardiovascular rehabilitation, the adherence of patients with heart disease is low. Thus, the alternative of telerehabilitation has gained importance, and many studies are being carried out to verify its efficacy.

To review the literature and assess the efficacy of telerehabilitation for the cardiac population.

This is a systematic review of the literature. The search was conducted in the electronic databases MEDLINE/PubMed (Medical Literature Analysis and Retrieval System Online), PubMed Central® (PMC), Cochrane Library, and Physiotherapy Evidence Database (PEDro), using the combination of descriptors, including terms of the Medical Subject Headings (MeSH) and its entry terms. The MeSH terms used in combination were: “telerehabilitation” AND “cardiac rehabilitation” (Table 1). Then, a manual search by use of the articles selected, as well as a search in the gray literature, was conducted.

The search strategy collected 154 studies, of which 109 were excluded because of duplication in the databases and 29 for not being clinical studies. Sixteen clinical studies were included for full analysis, of which 2 were excluded for being prospective, 2 for being duplicate and 5 for not including any outcome. Thus, 7 studies were included.

### Keywords

Cardiovascular Diseases; Cardiac Rehabilitation; Telerehabilitation; Physical Therapy Specialty; Review.

Cardiac rehabilitation using telerehabilitation is a feasible and safe alternative to conventional rehabilitation, and has high adherence of patients with heart disease. It can be added to conventional cardiovascular rehabilitation programs or used in isolation.

### Introduction

Cardiovascular diseases (CVD) are increasingly frequent. Their epidemiology has been compared to that of the great epidemics of the past centuries.<sup>1</sup> According to the World Health Organization (WHO), in recent decades, approximately 30% of a total of 50 million deaths were caused by CVD, 17 million people worldwide.<sup>2,3</sup>

Similarly, Brazil has equally alarming indices, with CVD as the major cause of death, representing 30% of all causes of death recorded, and being the third major cause of hospitalization in the country.<sup>2,3</sup> In addition, WHO states that those diseases are a threat to the socioeconomic development, mainly due to the large number of premature deaths that could be prevented by reducing the risk factors.<sup>4</sup>

Some nonpharmacological interventions are used to treat CVD, such as cardiovascular rehabilitation (CVR), consisting in the set of interventions aimed at improving the patients' physical, psychological and social conditions.<sup>5</sup> Over the past 40 years, the role of the CVR services in the secondary prevention of cardiovascular events has been recognized and accepted by health organizations, and the interventions used in the care provided to patients with CVD have proved fundamental to treat those individuals.<sup>6</sup>

Despite the confirmed CVR benefits, low adherence of the patients with CVD has been observed. Some studies have attributed it to the lack of transportation for the patients, lack of time, return to work or

#### Mailing Address: Danieli de Cristo

Rua Ludovico Della Mea, 685. Postal Code: 99040-170, Vera Cruz, Passo Fundo, RS - Brazil.

E-mail: danielidecristo@yahoo.com.br, danielidecristo2@gmail.com

financial problems, those being the major hindrances to participation in CVR programs. Some authors have reported that only 27% of the patients adhere to CVR.<sup>7</sup>

Therefore, different strategies to encourage physical exercise and changes in behavior and lifestyle are necessary and should be implemented to modify the patients' risk factors, preventing new cardiovascular events and enabling the patients' return to their usual daily activities.<sup>7</sup>

Considering all that and the recent technological advance, an alternative to conventional CVR has been the use of the technology of telemedicine,<sup>8</sup> which proposes the delivery of healthcare services by use of information and communication technologies in situations where a health professional and a patient (or two health professionals), each in a different place, can communicate in real time, or even enables data storage for further analysis, consultation and opinion. In addition, it provides the safe transmission of medical data via texts, sounds and images required for prevention, diagnosis, treatment and patients' follow-up.<sup>9</sup>

Rehabilitation using telemedicine resources is known as telerehabilitation and has gained importance. Several ongoing studies are assessing its efficacy, but they are heterogeneous and use different tools to conduct telerehabilitation. Thus, this study was aimed at reviewing the literature and assessing the efficacy of telerehabilitation for cardiac patients.

## Methodology

### Study design and search strategy

This is a systematic review of the literature, which does not require Ethics Committee in Research approval, but is being analyzed by the International Prospective Register of Systematic Reviews (PROSPERO). In addition, this systematic review has met the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The search was conducted in the electronic databases MEDLINE/PubMed (Medical Literature Analysis and Retrieval System Online), PubMed Central® (PMC), Cochrane Library, and Physiotherapy Evidence Database (PEDro), using the combination of descriptors, including terms of the Medical Subject Headings (MeSH) and its entry terms. The MeSH terms used in combination were: "telerehabilitation" AND "cardiac rehabilitation" (Table 1). Then, a manual search by use of the articles selected, as well as a search in the gray literature, was conducted.

**Table 1 - Search strategy used in PubMed**

#1	("Telerehabilitation"[mesh] OR "Telerehabilitations" OR "Tele-rehabilitation" OR "Tele rehabilitation" OR "Tele-rehabilitations" OR "Remote Rehabilitation" OR "Rehabilitation, Remote" OR "Rehabilitations, Remote" OR "Remote Rehabilitations" OR "Virtual Rehabilitation" OR "Rehabilitation, Virtual" OR "Rehabilitations, Virtual" OR "Virtual Rehabilitations")
#2	("Cardiac rehabilitation" [mesh] OR "Cardiac Rehabilitations" OR "Rehabilitation, Cardiac" OR "Rehabilitations, Cardiac" OR "Cardiovascular Rehabilitation" OR "Cardiovascular Rehabilitations" OR "Rehabilitation, Cardiovascular" OR "Rehabilitations, Cardiovascular")
#3	(randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR ("clinical trial"[tw]) OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR ("latin square"[tw]) OR placebos[mh] OR placebo*[tw] OR random*[tw] OR research design[mh:noexp] OR follow-up studies[mh] OR prospective studies[mh] OR cross-over studies[mh] OR control*[tw] OR prospectiv*[tw] OR volunteer*[tw]) NOT (animal[mh] NOT human[mh]))
#4	(#1 AND #2 AND #3)

### Inclusion and exclusion criteria

This study included all randomized or nonrandomized clinical trials found in the databases, published in Portuguese, English or Spanish, with the full text available and no date restriction, conducted in human beings aged at least 18 years, in which patients with CVD participated in CVR programs, using telerehabilitation or telemedicine resources.

Studies with the following characteristics were excluded: duplicate studies; not performed in human beings; not published in full text; whose population had been studied in more than one study and whose outcomes were similar, situations in which the first study was considered for inclusion in this review.

Two reviewers evaluated independently the abstracts. The studies selected had their full text assessed for inclusion according to the criteria established.

### Identification and selection of studies

Two reviewers independently read the titles and abstracts of each pre-selected study, identifying



## Results

This systematic review gathered 154 studies identified through the determined search strategy in electronic databases. Of those 154 studies, 109 were excluded due to duplication in databases, 29 were excluded because of being abstracts, systematic reviews or other studies. Thus, 16 clinical trials were included for complete analysis, of which 2 were excluded because of their prospective character, 2 were excluded due to cohort duplication, and 5 were excluded for not contemplating an outcome. Thus, 7 studies were included for complete analysis in this review (Figure 1).

Data regarding the methodology and results of the studies included in this review are shown in Table 3. They assessed the effectiveness of telerehabilitation as compared to conventional CVR, in addition to comparing the effectiveness of conventional CVR to that of hybrid cardiac rehabilitation (HCR), in which the patient practices the exercises at home using sensors that transmit information to the rehabilitation center. Some studies' outcomes were as follows: influence of rehabilitation on oxygen consumption ( $VO_2$ ), physical capacity, acceptance and efficacy of the technique in different patients. Of the underlying pathologies that

led the patients to look for rehabilitation, the following stand out: coronary artery disease (CAD), chronic heart failure (CHF) and diabetes mellitus (DM).

## Discussion

The present systematic review of the literature analyzed seven clinical trials involving telerehabilitation for patients with CVD, adding up to a sample of 1,133 patients. The studies were heterogeneous regarding both their populations and interventions; thus, a meta-analysis could not be performed.

Catalina et al.<sup>10</sup> have suggested that CAD is still one of the major causes of premature death in Europe and worldwide, being considered a public health problem. Considering that, some studies have assessed the effects of CVR and telerehabilitation on patients with CAD. According to Vieira et al.,<sup>11</sup> the group undergoing telerehabilitation performed better in executive functions, conflict resolution and attention as compared to the group undergoing conventional CVR. According to Brouwers et al.,<sup>12</sup> telerehabilitation has provided better physical activity levels in the long run as compared to conventional CVR. Likewise, other authors have evidenced that patients with CAD

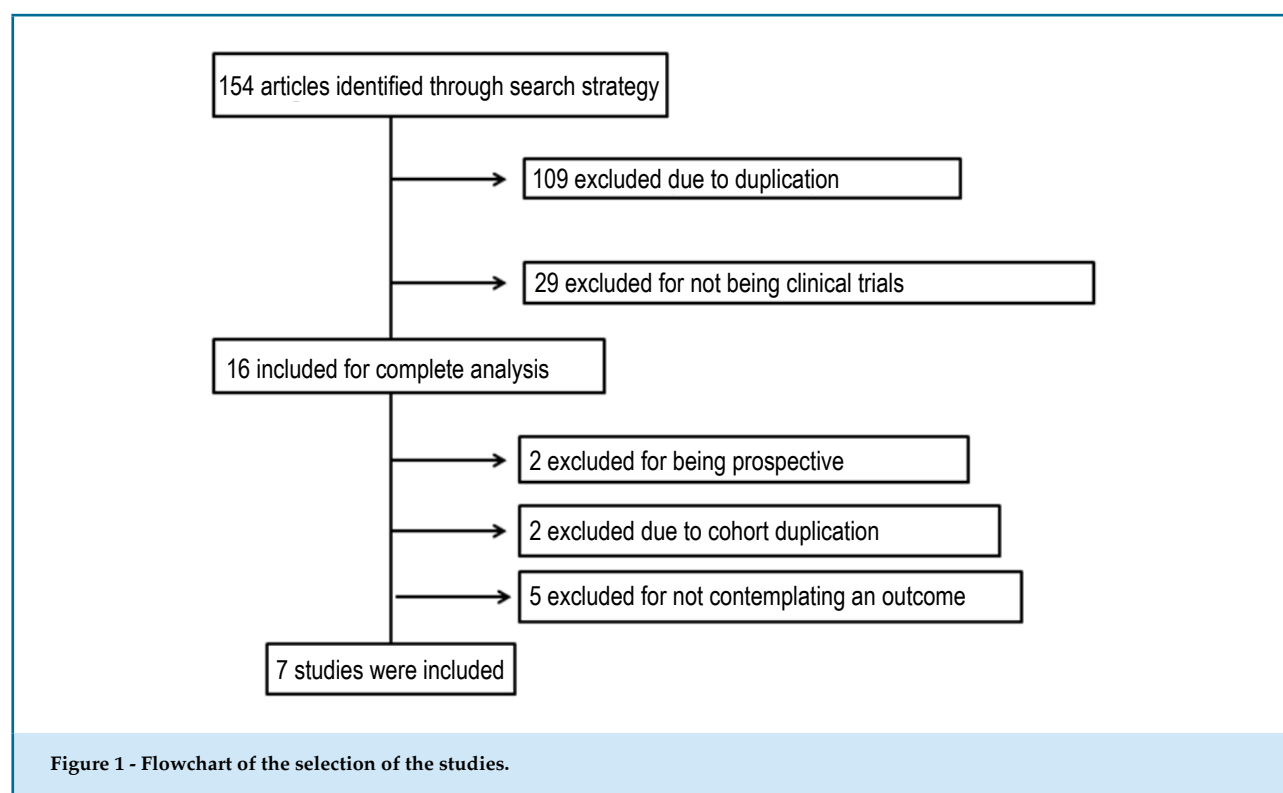


Figure 1 - Flowchart of the selection of the studies.

**Table 3 - Methodology and results of the studies included**

Author/Year	Groups	N	Objective	Technique / Instruments	Conclusion
Vieira et al., <sup>11</sup> 2017	G1 = home CVR + Kinect G2 = home CVR + booklet G3 = usual care	N = 33 G1 = 11 G2 = 11 G3 = 11	To assess the effect of a home-based phase III CVR specific exercise program, for 6 months, on changes in executive function, quality of life and depression, anxiety and stress of individuals with CAD.	Compared G1 x G2 x G3 G1 = Specific Kinect software G2 = Booklet with exercises G3 = Guidance on risk factors and encouragement of walking	G1 showed better performance regarding executive function, mainly in conflict resolution and attention.
Brouwers et al., <sup>12</sup> 2017	CG = CVR at a center IG = home-based telerehabilitation	N = 300 GC = 150 GI = 150	To compare cardiac telerehabilitation with conventional CVR, regarding behavior change and physical activity level in patients with CAD.	IG: Web App for patients to adjust their rehabilitation goals, inspect their trainings and physical activity data; such data are shared, and video consultation is available; heart rate monitor; accelerometer.	Telerehabilitation using modern technology and behavior change strategies results in better long-term physical activity levels as compared to conventional CVR for patients with CAD.
Piotrowicz et al., <sup>15</sup> 2015	CG = control TG = home-based telerehabilitation	N = 111 GC = 77 GT = 34	To assess the influence of reversion of depression (Beck score) and physical capacity improvement (VO <sub>2</sub> peak) in patients with CAD.	TG: 5-10-minute warm-up, Nordic training (walking) for 15-45min, and 5-minute cool-down. Patients trained 5 times per week, for 8 weeks, and received an instrument for data transmission through the cellular phone. CG: No exercise prescription. All participants were instructed on healthy lifestyle.	Home-based rehabilitation using telerehabilitation resulted in reversion of depression and improvement in physical capacity of patients with CHF.
Bernocchi et al., <sup>16</sup> 2017	IG = intervention/ telerehabilitation group CG = control group	N = 112 GI = 56 GC = 56	To assess the feasibility and efficacy of an integrated home-based telerehabilitation program in patients with COPD + CHF.	IG: weekly phone calls, instructions/lifestyle, supervised exercise with oximeter; CG: medications, O <sub>2</sub> and visits, instructions on how to practice the exercise of their choice, without supervision.	The IG increased the walked distance, while the CG showed no significant improvement. MRC dyspnea scale and Barthel index improved in IG as compared to CG in 4 months. IG kept the benefits acquired for 6 months. This 4-month telerehabilitation program was feasible and effective for patients with COPD and CHF.

Szalewska et al., <sup>13</sup> 2015	CRD = cardiac rehabilitation with DM CCR = cardiac rehabilitation without DM	N = 125 RCD = 37 RCC = 88	To compare the effects of HCR in patients with CAD with and without DM.	Both groups trained for 10 days at the rehabilitation center, received instructions, and then passed to home-based rehabilitation, during which they were monitored with tele-ECG and trained with supervised exercises. The device enabled recording ECG data from 3 precordial leads and their transmission through a cellular phone network to the monitoring center. A cellular phone was also used for daily voice communication between the patient and the doctor who asked about the patient's health status.	HCR was effective for patients with DM. Adherence to HCR was high. Patients with DM had higher rates of obesity and significantly lower tolerance to exercise than those without DM. Patients of both groups had similar benefits regarding physical capacity, heart rate at rest and heart rate recovery.
Korzeniowska-Kubacka et al., <sup>17</sup> 2015	Men after AMI: 57 Women after AMI: 30	N = 87	To compare the influence of HCR on the physical capacity, safety, adherence and return to work of post-AMI male and female patients.	Ten rehabilitation sessions were performed at the center, and the others at home with tele-ECG monitoring. Before and after the trainings, all patients underwent a symptom-limited exercise stress test. The evaluation included the results of exercise tests.	HCR resulted in a comparable improvement in physical capacity in post-AMI low-risk male and female patients. Although HCR facilitated patients' adherence to the training program, their return to work was significantly greater only in post-AMI men.
Piotrowicz et al., <sup>18</sup> 2014	Telerehabilitation Group: all participants practiced 3 days at a center and 4 months at home.	N = 365	To assess the implementation and feasibility of a wide home-based cardiac telerehabilitation program for patients with CVD, as well as its safety, and the patients' acceptance and adherence to the program.	Participants underwent a 4-week HCR based on walking, Nordic walking or cycle ergometer training. They were monitored via telephone with a device to record ECG and to transmit data via cellular phone to the monitoring center. Automatic ECG recording was pre-defined and coordinated. The influence on physical capacity was assessed by comparing the changes in: time of the exercise test, functional capacity, distance in 6-minute walk test at the beginning and end of the program. All participants used an APP for ECG and BP transmission.	HCR resulted in a significant improvement in all parameters. It is a feasible and safe form of rehabilitation, well accepted by patients. The adherence to HCR was high and promising.

*Kinect: movement sensor; Booklet: with information and guidance about the practice of the exercises; CAD: coronary artery disease; CHF: chronic heart failure; COPD: chronic obstructive pulmonary disease; DM: diabetes mellitus; AMI: acute myocardial infarction; CVD: cardiovascular disease; Tele-ECG: electrocardiogram transmission system; HCR: hybrid cardiac rehabilitation; APP: application for data transmission; MRC: Medical Research Council; BP: blood pressure.*



submitted to telerehabilitation showed a significant increase in their daily activity level and VO<sub>2</sub> peak after 6 weeks.

Hybrid cardiac rehabilitation has been used for patients with CAD. Szalewska et al.<sup>13</sup> have compared the use of that technique in patients with CAD and DM and patients with DAC but without DM. Those authors have reported that adherence to HCR was high, and that HCR was effective in patients with and without DM.

According to Bocchi et al.,<sup>14</sup> heart failure (HF) is the common end of most heart diseases, being classified as an epidemic and representing one of the most important current clinical challenges in health care. Telemedicine has been increasingly used for that population. In a clinical study with 111 patients with HF, Piotrowicz et al.<sup>15</sup> have shown that home-based rehabilitation using telerehabilitation caused reversion of depression and improved physical capacity in those patients.

Corroborating the results demonstrated, Bernocchi et al.<sup>16</sup> have suggested, in a study with 112 patients diagnosed with HF and chronic obstructive pulmonary disease (COPD), that a home-based telerehabilitation program increased the walked distance, reduced the dyspnea and improved the functionality of those individuals as compared to those of the group undergoing conventional CVR, confirming the feasibility and effectiveness of telerehabilitation programs for patients with HF and COPD.

Hybrid cardiac rehabilitation has also been used for post-acute myocardial infarction (AMI) patients. In a study with 87 post-AMI patients, the authors have evidenced that HCR facilitated patients' adherence to the training program, but the return-to-work indices were higher in men than in women, although the physical capacity improvement was similar for both sexes.<sup>17</sup>

Similarly to the studies assessed, Piotrowicz et al.<sup>18</sup> have confirmed in a sample of 365 patients that HCR using telerehabilitation resulted in a significant improvement in functional capacity, being a feasible,

safe and well accepted rehabilitation form, with a high index of patients' adherence.

## Conclusion

After analyzing the studies, we concluded that HCR and home-based rehabilitation using telerehabilitation are feasible and safe alternatives, with high adherence by patients with CVD. They can be added to conventional CVR programs or be used in isolation. In addition, they help to improve depression, functional capacity and the physical activity level.

## Author contributions

Conception and design of the research: Cristo D, Dias AS, Sachetti A. Acquisition of data: Cristo D, Nascimento NP, Sachetti A. Analysis and interpretation of the data: Cristo D, Nascimento NP, Sachetti A. Statistical analysis: Cristo D. Writing of the manuscript: Cristo D, Sachetti A. Critical revision of the manuscript for intellectual content: Cristo D, Dias AS, Sachetti A.

## Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

## Sources of Funding

There were no external funding sources for this study.

## Study Association

This study is not associated with any thesis or dissertation work.

## Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

## References

1. Simão AF, Prêcoma DB, Andrade JP, Correa Filho H, Saraiva JF, Oliveira GM; Brazilian Society of Cardiology. I cardiovascular prevention guideline of the Brazilian Society of Cardiology - executive summary. *Arq Bras Cardiol.* 2014;102(5):420-31.
2. Braig S, Peter R, Nagel G, Hermann S, Rohrmann S, Linseisen J. The impact of social status inconsistency on cardiovascular risk factors, myocardial infarction and stroke in the EPIC-Heidelberg cohort. *BMC Public Health* 2011 Feb 16;11:104.

3. Tuan TS, Venâncio TS, Nascimento LF. Effects of air pollutant exposure on acute myocardial infarction, according to gender. *Arq Bras Cardiol.* 2016;107(3):216-22.
4. Duncan BB, ChorII D, Aquino EML, Bensenor IM, Mil JG, SchmidtI MI, et al. Chronic non-communicable diseases in Brazil: priorities for disease management and research. *Rev Saúde Pública.* 2012;46(Suppl):126-34.
5. Trevisan MD. Reabilitação cardiopulmonar e metabólica fase i no pós-operatório de cirurgia de revascularização do miocárdio utilizando cicloergômetro: um ensaio clínico randomizado. [Dissertação]. Porto Alegre: Pontifícia Universidade Católica do Rio Grande do Sul - Programa de Pós-graduação em Gerontologia Biomédica; 2015.
6. Herdy AH, López-Jimenez F, Terzic CP, Milani M, Stein R, Carvalho T; Sociedade Brasileira de Cardiologia. South American guidelines for cardiovascular disease prevention and rehabilitation. *Arq Bras Cardiol.* 2014;103(2 Suppl 1):1-31.
7. Frederix I, Vanhees L, Dendale P, Goetschalckx K. A review of telerehabilitation for cardiac patients. *J Telemed Telecare.* 2015;21(1):45-53.
8. Piotrowicz E. How to do: telerehabilitation in heart failure patients. *Cardiol J.* 2012;19(3):243-8.
9. Oliveira Jr MT, Canesin MF, Marcolino MS, Ribeiro AL, Carvalho AC, Reddy S, et al; Sociedade Brasileira de Cardiologia. [Telemedicine guideline in patient care with acute coronary syndrome and other heart diseases]. *Arq Bras Cardiol.* 2015;104(5 Suppl. 1):1-26.
10. Catalina CO, Adina B, Smarandita BE, Angela D, Dan G, Silvia M. Cardiovascular lipid risk factors and rate of cardiovascular events after myocardial revascularization. *Int J Cardiovasc Sci.* 2017;30(1):4-10.
11. Vieira A, Melo C, Machado J, Joaquim Gabriel. Virtual reality exercise on a home-based phase III cardiac rehabilitation program, effect on executive function, quality of life and depression, anxiety and stress: a randomized controlled trial. *Disabil Rehabil Assist Technol.* 2018;13(2):112-23.
12. Brouwers RW, Kraal JJ, Traa SC, Spee RF, Oostveen LM, Kemps HM. Effects of cardiac telerehabilitation in patients with coronary artery disease using a personalised patient-centred web application: protocol for the SmartCare-CAD randomised controlled trial. *BMC Cardiovasc Disord.* 2017;17(1):46.
13. Szalewska D, Zieliński P, Tomaszewski J, Kusiak-Kaczmarek M, Łepska L, Gierat-Haponiuk K, et al. Effects of outpatient followed by home-based telemonitored cardiac rehabilitation in patients with coronary artery disease. *Kardiol Pol.* 2015;73(11):1101-7.
14. Bocchi EA, Marcondes-Braga FG, Bacal F, Ferraz AS, Albuquerque D, Rodrigues Dde A, et al. [Updating of the Brazilian guideline for chronic heart failure - 2012]. *Arq Bras Cardiol.* 2012;98(1 Suppl 1):1-33.
15. Piotrowicz E, Piotrowski W, Piotrowicz R. Positive effects of the reversion of depression on the sympathovagal balance after telerehabilitation in heart failure patients. *Ann Noninvasive Electrocardiol.* 2016;21(4):358-68.
16. Bernocchi P, Vitacca M, La Rovere MT, Volterrani M, Galli T, Baratt D, et al. Home-based telerehabilitation in older patients with chronic obstructive pulmonary disease and heart failure: a randomised controlled trial. *Age Ageing.* 2018;47(1):82-88.
17. Korzeniowska-Kubacka I, Bilińska M, Dobraszkievicz-Wasilewska B, Piotrowicz R. Hybrid model of cardiac rehabilitation in men and women after myocardial infarction. *Cardiol J.* 2015;22(2):212-8.
18. Piotrowicz E, Korzeniowska-Kubacka I, Chrapowicka A, Wolszakiewicz J, Dobraszkievicz-Wasilewska B, Batogowski M, et al. Feasibility of home-based cardiac telerehabilitation: results of TeleInterMed study. *Cardiol J.* 2014;21(5):539-46.

