Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XXIV, ISSUE 2 Supplement, 2024, Romania
The journal is indexed in: ERIH PLUS, Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST, DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengage Learning, Cabell's Directories

Science, Movement and Health, Vol. XXIV, ISSUE 2 Supplement, 2024
September 2024, 24 (2): 237-248
Original article

ASSESSMENT OF PATIENTS WITH SURGICALLY OPERATED VALVULOPATHIES AFTER MEDICAL REHABILITATION PROGRAM

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Abstract

Aim. According to the World Health Organization (2021), cardiovascular diseases are the leading cause of death worldwide, claiming approximately 17.9 million lives each year. The aim of this study is to present an original 8-day cardiac rehabilitation programme and to analyse the effects of the programme based on the results of monitoring and evaluation of selected patients.

Methods. Physiotherapy, through the effects induced on the systems that make up the human body, especially on the respiratory and cardiovascular systems, is the main modality of therapeutic intervention in the rehabilitation of patients with surgically corrected valvulopathies to ensure functional independence. Wenger (1986), proposed the first cardiac rehabilitation programme, the aim of which was for the patient to move from a supine position to a sitting position and then to move around within 14 days. The original cardiac rehabilitation program becomes a training program similar to the sports training program, representing a systematic and continuous graded pedagogical process of adapting the human body to physical and mental efforts.

Results. In this study we present, analyze and interpret data obtained from dynamic measurements (in-patient, intermediate and discharge assessment evaluation) to confirm or reject hypotheses and to draw research conclusions on the effects of the original cardiac rehabilitation program for subjects with surgically corrected valvulopathy.

Conclusions. The conclusions of this study validate the research hypothesis that the application of the original cardiac rehabilitation program leads to increased effort capacity and quality of life in patients with valvulopathies surgically corrected by minimally invasive techniques.

Keywords: valvulopathy, physiotherapy, original cardiac rehabilitation program, quality of life.

Introduction

Cardiovascular disease is defined as a group of diseases of the heart and blood vessels, including cerebrovascular disease, coronary heart disease, rheumatic heart disease and other conditions, and according to the World Health Organization (2021), they are the leading cause of death worldwide, claiming approximately 17.9 million lives each year. The World Health Organization (2021) specifies that more than four out of five deaths from vascular diseases are due to myocardial infarction and stroke, and one third of these deaths occur prematurely in people under 70 years of age.

Valvulopathies are functional or organic diseases that occur in the heart valves, affecting one or more heart valves by disturbing their closing or opening. The surgical intervention consists of replacing the heart valve with a prosthesis using extracorporeal circulation.

Physiotherapy, through the effects induced on the systems that make up the human body, especially on the respiratory and cardiovascular systems, is the main therapeutic intervention modality in the rehabilitation of patients with surgically corrected valvulopathies to ensure functional independence.

Medical rehabilitation addresses the impact of a health condition on a person's daily life by optimizing their functioning and reducing their experience of disability.

According to the World Health Organization (2023), medical rehabilitation expands the focus of health beyond preventive and curative care to ensure that people with a health condition can remain as independent as possible and participate in education, work and meaningful roles in life.

Medical rehabilitation, according to Cieza (2019), represents the interventions needed when a person faces limitations in everyday physical, mental and social functioning due to aging or a health condition, including non-communicable diseases or disorders, injuries or trauma .

In the late '80s, Wenger (1986) proposed the first cardiac rehabilitation program, the goal of which was to transition from the supine position to the sitting position and walking in the corridor under medical supervision of the patient within 14 days. Wenger et al. (1999) believe that another challenge for the 21st century will be the selection, development and delivery of appropriate rehabilitation services to individual cardiac patients with adaptation of the cardiac rehabilitation method.

Seo et al. (2017) based on the research results of their study, recommended that rehabilitation programs with physical exercises, for patients in the hospitalization period, be led by specialists, such as: physiotherapists.

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Sumide et al. (2009) based on study data suggest that exercise intolerance in patients with surgically corrected valvulopathies depends on decreased muscle strength. Further studies are needed to evaluate whether the strategy of increasing lower limb muscle strength through resistance training could be effective for improving exercise capacity.

Aerobic training programs supplemented with resistance exercise are, for Price et al. (2016), recommended and considered safe for patients undergoing cardiac rehabilitation programs, with specialists in the field and based on research evidence, this may provide superior patient outcomes and should therefore be considered when developing a international consensus for exercise prescription in cardiac rehabilitation.

The definition of quality of life includes a reference to a person's physical state, measured using standardised parameters, but it will not be assessed solely on the basis of bodily functions, it will be correlated with the degree of perceived satisfaction with this level of functionality.

Engel (1977) developed the biopsychosocial model, in which he stated that in order to understand a person's medical condition, not only biological factors but also psychological and social factors must be considered. This type of definition, according to Irtelli & Durbano (2020), shifts the focus from objectively definable functionality to the dimension of subjectivity, and the detection of these two aspects can be a reliable measure of quality of life.

The aim of this study is to present an original 8-day cardiac rehabilitation programme and to analyse the effects of the programme based on the results of monitoring and evaluation of selected patients. Through the present study, we aimed to verify the following hypothesis: the application of the original cardiac rehabilitation program leads to an increase in effort capacity and quality of life in patients with valvulopathies surgically corrected by minimally invasive techniques.

Premises

In designing this study we started from the following premises:

- through the effects induced on the systems that make up the human body, especially on the respiratory and cardiovascular systems, physiotherapy is the main therapeutic intervention to ensure the functional independence of patients with surgically corrected valvulopathies;
- the review of the national literature did not reveal any studies in which the approach to medical rehabilitation of patients with surgically corrected valvulopathies is carried out through a medical rehabilitation programme based on the trinomial: pulmonary, cardiac and musculoskeletal rehabilitation;
- the methods and techniques used in cardiac rehabilitation are based on pathophysiological mechanisms, which require the selection of appropriate therapeutic means.

Methods

Subjects and research location

The study was carried out in a centre of excellence in cardiovascular surgery in Bucharest between June 2023 and December 2023.

In the hospital, which specialises in performing complex surgery and integrated post-operative medical services, there is the necessary equipment to perform and monitor the tests included in the original cardiac rehabilitation program for patients with surgically corrected valve disease. At the same time, the hospital also has the advantage of a physiotherapy room equipped with equipment and devices for the rehabilitation of patients with surgically corrected valvulopathies using minimally invasive techniques.

Ten subjects were selected for the study according to inclusion certain criteria.

The *inclusion criteria* used were:

- valvulopathies surgically corrected by minimally invasive techniques (aortic stenosis - AoS or mitral insufficiency - MiI);
- good general condition;
- age: 55 – 65 years;
- consent to participate in the study.

The *exclusion criteria* used were:

- complex interventions with surgically corrected valvulopathies and coronary bypass;
- age < 55 years old or > 65 years old.

Table 1 shows the characteristics of the subjects included in the study, grouped by age, sex, height and weight.

Table 1. Data about study participants

Item no.	Initials	Age (years)	Gender	Height (cm)	Weight (kg)
1	B.GH.	65	M	178	82
2	F.L.	56	F	164	90
3	M.C.	64	M	164	86
4	M.F.	65	F	160	78
5	P.V.	55	M	173	91
6	C.O.G.	57	M	186	108
7	B.G.	65	M	190	126
8	M.F.	60	F	157	70
9	S.C.M.	56	F	148	62
10	M.M.	64	M	180	97

Therapeutic intervention on researched subjects

To evaluate the level of cardiac rehabilitation of patients with surgically corrected valvular heart disease by minimally invasive procedures in this study we propose the following measurements and tests, adapted to the subjects' possibilities.

The original cardiac rehabilitation program includes the following stages:

- *Evaluation at admission - Initial functional assessment in hospital*

  In this study to estimate and assess the initial level of preoperative effort capacity, we calculated and monitored the following parameters and test:
  - Heart rate (HR), using a pulse oximeter;
  - Blood pressure (BP), systolic and diastolic, with a digital blood pressure monitor at the beginning and end of the assessment;
  - Oxygen saturation (SpO_2), using a pulse oximeter;
  - Maximum oxygen consumption (VO_2max);
  - The 6-Minute Walk Test (6MWT) taken on in-patient admission.
- *Intermediate evaluation – Physiotherapy cardiac program*

  The intermediate evaluation of the subjects investigated was carried out on days 1, 3, 5 and 8, at the beginning and at the end of the session applied on that day in the cardiac rehabilitation program.
- *Evaluation at discharge - Final functional assessment at the time of patient discharge*

  In the final functional evaluation, we again measured the monitored functional parameters, whose values determine the patient's level of effort capacity after the cardiac rehabilitation program and before discharge. In this final evaluation, we applied the proposed Quality-of-Life Assessment questionnaire (QLHR-Q10), a questionnaire that measures the quality of life after the cardiac rehabilitation program, by examining and analyzing the answers that the subject can give on a Likert scale, and the control question questionnaire SQ100 and the 6MWT performed at hospital discharge.
- *Cardiac rehabilitation in intensive care unit (ICU)*

  In his study Geppert (2013) points out that the accentuation of valvular dysfunction becomes relevant and increases with age, reaching more than 10% in patients over 75 years of age. Guidelines and studies on the treatment of these patients, especially in an intensive care unit (ICU), are however rare, even though there are updated guidelines for the treatment of valvular heart disease in the general population.

  The study by Mendez-Tellez & Needham (2012) re-evaluates the growing evidence demonstrating the feasibility and safety of early physical rehabilitation interventions for mechanically ventilated patients and their benefits on patient outcomes.

  Norrenberg et al. (2000) created a profile of the role of the physiotherapist in Europe in the ICU, stating that in almost 100% of ICUs, the physiotherapist performed respiratory rehabilitation, mobilisation and positioning. It played an active role in regulating mechanical ventilation in 12% of respondent units, in disconnecting from mechanical ventilation in 22% of wards, in detubating in 25% and in implementing non-invasive mechanical ventilation in 46%. In the ICU, the cardiac rehabilitation programme starts with the identification of all risk factors so that their assessment can provide a correct and preventive solution; due to prolonged rest in the ICU a physical, functional and movement impairment occurs which can be prevented by a programme of active and passive mobilisations for the upper and lower limbs followed by monitoring of breathing exercises.
- *The physiotherapy program*

  The original cardiac rehabilitation program becomes a training program similar to the sports training program, representing a systematic and continuous graded pedagogical process of adapting the human body to physical and mental efforts. The physiotherapy program includes rehabilitation exercises structured by days according to the Assisted Physical Activities (AFA) scheme.

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Results

In the following we present, analyze and interpret data obtained from dynamic measurements (in-patient, intermediate and out-patient evaluation) to confirm or reject hypotheses and to draw research conclusions on the effects of the original cardiac rehabilitation program for subjects with surgically corrected valvulopathy.

The initial evaluation included measurements of HR, BP, SpO_2, VO_2max and 6MWT, measurements reflecting effort capacity at the time of hospital admission. In the intermediate evaluation, the measurements mentioned were performed on the following days: 1, 3, 5, 8 of the cardiac rehabilitation program, both at the beginning and at the end of the program applied on that day. Evaluation at discharge included patient participation in the completion of the QLHR-Q10, the control question questionnaire SQ100 and assessment of the patient's exercise capacity at the time of discharge from hospital.

Analysis and interpretation of the results

The analysis of the data series contains as a first step the descriptive statistics for the group of participants in the present research (N=10), data centralized in Table 2.

Table 2. Descriptive statistics

	Mean	Standard error	Median	Module	Standard deviation	Kurtosis	Skewness	Range	Min	Max	Confidence interval
Age	60.7	1.37	62	65	4.32	-2.16	-0.23	10	55	65	3.09
Gen	0.6	0.16	1	1	0.52	-2.28	-0.48	1	0	1	0.37
HRa	73.3	2.69	72	72	8.51	0.61	0.56	30	60	90	6.09
HRd	67.2	1.51	66.5	62	4.78	-0.54	0.65	14	62	76	3.42
SBPa	130	5.56	133		17.59	-0.66	-0.35	56	100	156	12.59
DBPa	79.2	2.15	80.5	83	6.80	0.03	-0.63	22	66	88	4.86
SBPd	112.6	2.20	111	110	6.96	-0.88	-0.04	22	101	123	4.98
DBPd	66.7	0.99	67.5	69	3.13	-0.71	-0.71	9	61	70	2.24
SpO_2a	92.4	0.43	93	93	1.35	-0.76	-0.58	4	90	94	0.97
SpO_2d	98.5	0.37	98	98	1.18	-1.44	0.25	3	97	100	0.84
VO_2maxa	26.1	0.97	27	22	3.07	-1.73	-0.29	8	22	30	2.20
VO_2maxd	31.9	1.33	32.5	37	4.20	-1.47	-0.25	11	26	37	3.01
6MWTa	275.5	12.28	275		38.84	0.16	0.47	128	222	350	27.78
Predicted	381.7	16.78	389.5		53.05	-0.85	0.01	163	307	470	37.95
6MWTFd	397.3	17.14	403.5		54.21	-0.71	0.21	169	324	493	38.78

All our variables are continuous and measured on ratio scale, so we will analyze the mean. There is one exception, the gender variable which is measured on a nominal scale and for which we calculate the mode. The modulus takes the value 1, which highlights that we have more men than women. We now present the main statistical indicators:

The analyzed values from Table 2 are:

1. *Mean* showing the central tendency of each individual series (Table 2);
2. *Standard deviation* denotes the degree of dispersion of the data. In general, it compares with values of central tendency. In the case of our variables, it is reasonable (Table 2);
3. *Kurtosis values* evaluate the sharpness of the graph. Values in the range [-1.96; 1.96] denotes a graph that closely approximates the Gaussian curve of the normal. Very sharp curves for gender and age are observed, as patient ages are advanced, ranging from [55, 65] and gender is predominantly 1 (male);
4. *Skewness values* evaluate the shift of the graph to the left or right from the normal values. Values in the range [-1.96; 1.96] denotes a graph that closely approximates the Gaussian curve of the normal. All the values of our variables fall within this range (Table 2);
5. *Min* and *Max* – represent the minimum and maximum values respectively contained in our data series;
6. *Range* – represents the difference between the maximum values and the minimum values;
7. *Confidence interval* - represents the margin within which the average can juggle.

Because our variables are measured on ratio scale and have approximately normal distribution, we can apply parametric tests on them i.e. T-test.

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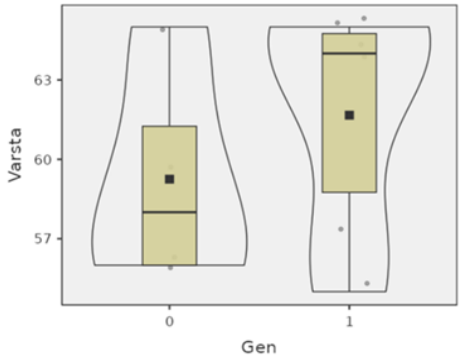
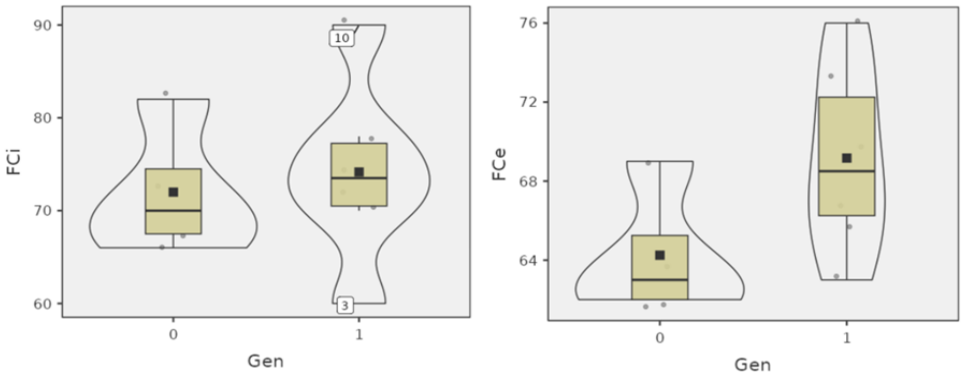


Figure 1. Age distribution by gender

In the case of our study the age of the subjects is advanced, with an average of 60.7 years, and being in the range [55; 65]. Pathology generally occurs at older ages due to degenerative factors (Table 2). In our sample the mean age of women is lower, tending towards 58 years, with an exception of 65 years (the graph occupies a larger area in the lower part, which also contains the mean=horizontal line), and the mean age of men is higher, tending towards 64 years (the graph occupies a larger area in the upper part, which also contains the mean=horizontal line). Men have extreme ages respectively 55 or 65 (Figure 1).

Heart rate (HR)

HR at admission averaged 73.3 bpm with a standard deviation (SD) of 8.51, with extreme values in the range [60;90] (Table 2). Mean HR values at admission tend towards 70bpm in women and 71bpm in men. However, the women's sample is more homogeneous (the graph occupies a larger area in the lower part, which also contains the mean=horizontal line), and the men's sample contains the minimum and maximum values, the ends of the range, so the graph takes the shape of an amphora (Figure 2a).



a) evaluation on admission b) evaluation at discharge

Figure 2. Distribution of HR according to gender

HR at discharge of 67.2 bpm with a standard deviation of 4.78, with extreme values in the range [62; 76] (Table 2).

Mean HR values at discharge tend towards 61 bpm in women and 69 bpm in men. However, the female sample is more homogeneous (the graph occupies a larger area in the lower part, which also contains the mean=horizontal line) and the male sample contains the minimum and maximum values, the ends of the range, so the graph takes the shape of an oval (Figure 2b). Thus, following the application of the original cardiac rehabilitation program HR decreased and at discharge the group is more homogeneous, having a lower SD (half of the original one).

Systolic blood pressure (SBP)

The patient's SBP on admission has a mean of 130 mmHg with a standard deviation (SD) of 5.56, with extreme values in the range [100;156] (Table 2). Mean values of patient SBP at admission tend toward 126 mmHg in women and 130 mmHg in men. The female sample contains lower values than the male sample (Figure 3a).

SBP at discharge has a mean of 112.6 mmHg with a standard deviation (SD) of 2.2, with extreme values in the range [101;123]. Mean values of SBP at discharge tend towards 110 mmHg in women and 113 mmHg in men. The women's sample contains lower values than the men's (Figure 3b).

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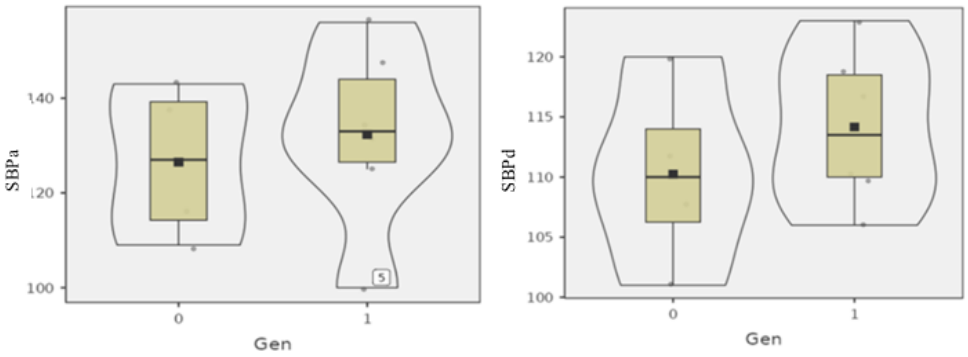


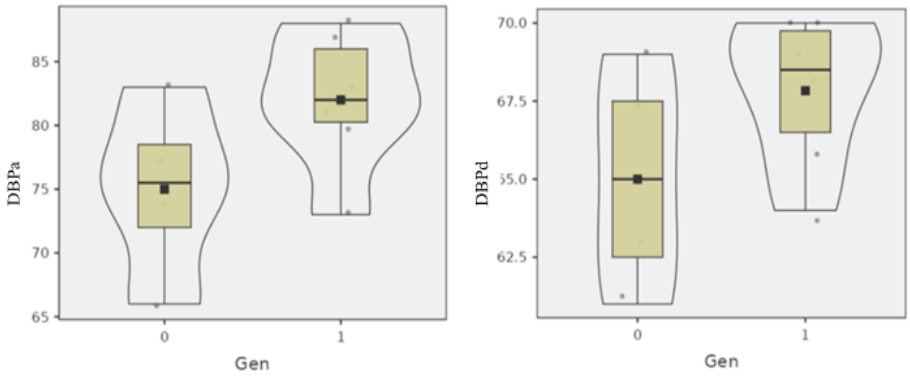
a) evaluation on admission b) evaluation at discharge

Figure 3. Distribution of SBP according to gender

Thus, following *the application of the original cardiac rehabilitation programme, SBP decreased and at discharge the group is more homogeneous*, having a lower SD (half of the original one).

Diastolic blood pressure (DBP)

DBP at admission has a mean of 79.2 mmHg with a standard deviation (SD) of 6.8, the extreme values being in the interval [66;88] (Table 2). Average DBP values at admission tend to be 76 mmHg in women and 83 mmHg in men. The female sample contains lower values than the male sample (Figure 4a).



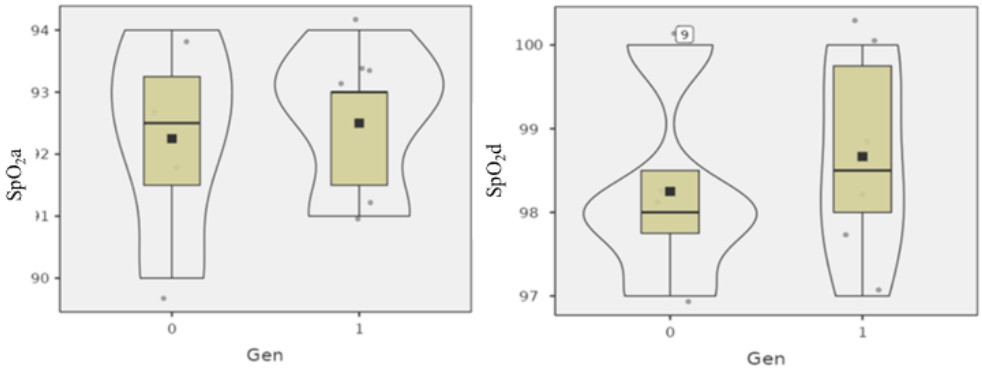
a) evaluation on admission b) evaluation at discharge

Figure 4. Distribution of DBP according to gender

DBP at discharge has a mean of 66.7 mmHg with a very small standard deviation (SD) of 3.13, the extreme values being in the interval [61;70]. Mean DBP values at discharge tend to be 65 mmHg in women and 68 mmHg in men. The women's sample contains lower values than the men's (Figure 4b). Thus, following *the application of the original cardiac rehabilitation program, the DBP decreased, and at discharge the group is more homogeneous*, having a lower SD.

Oxygen saturation (SpO_2)

SpO_2 at admission has a mean of 92.4% mmHg with a standard deviation (SD) of 1.35, the extreme values being in the interval [90;94] (Table 2). Average values of SpO_2 at admission tend to 92.5% in women and 93% in men. The female sample contains lower values than the male sample. The male sample is more homogeneous (Figure 5a).



a) evaluation on admission b) evaluation at discharge

Figure 5. Distribution of SpO_2 according to gender

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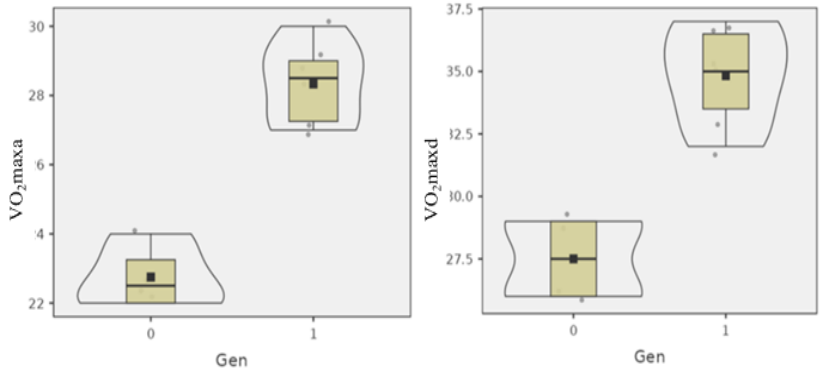
SpO_2 at discharge has a mean of 98.5% with a very small standard deviation (SD) of 1.18, the extreme values being in the range [97;100]. Average SpO_2 values at discharge tend to 98% in women and 98.5% in men. The female sample contains lower values than the male sample (Figure 5b). Thus, following the application of the original cardiac rehabilitation program SpO_2 increased, even reaching the maximum value (100) in some cases, so *the original cardiac rehabilitation program was good*, from the point of view of the measured values of SpO_2.

Maximum oxygen consumption (VO_2max)

VO_2max at admission has a mean of 26.1 ml/kg/min with a standard deviation (SD) of 3.07, the extreme values being in the interval [22;30] (Table 2). Mean values of VO_2max on admission tend to be 22 ml/kg/min in women and 29 ml/kg/min in men. The female sample contains much lower values than the male sample (Figure 6a).



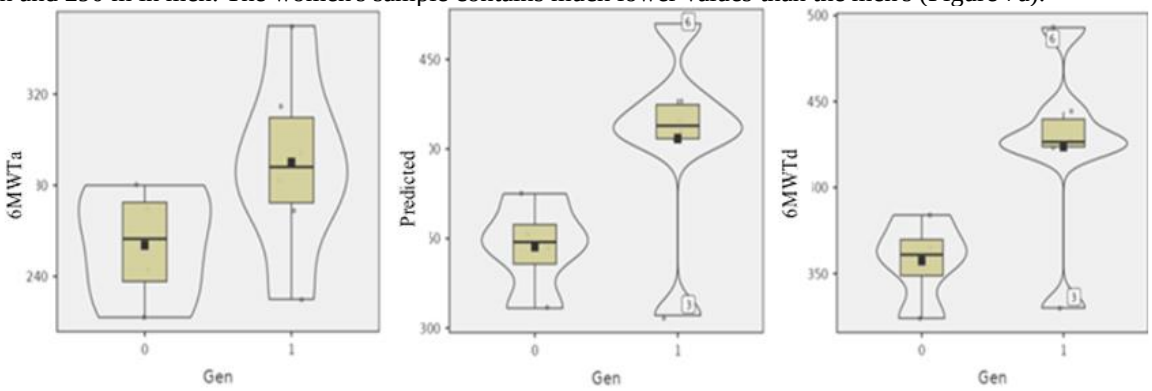
a) evaluation on admission b) evaluation at discharge

Figure 6. Distribution of VO_2max according to gender

VO_2max at discharge has a mean of 31.9 ml/kg/min with a very small standard deviation (SD) of 4.2, the extreme values being in the range [26;37]. Mean values of VO_2max at discharge tend to 27.5 ml/kg/min in women and 35 ml/kg/min in men. The female sample contains lower values than the male sample (Figure 6b). Thus, following the application of the original cardiac rehabilitation program VO_2max increased, so *the original cardiac rehabilitation program was good*, from the point of view of the measured values of VO_2max.

The 6-Minute Walk Test (6MWT)

The values obtained at 6MWTi at admission have an average of 275.5 m with a standard deviation (SD) of 34.84, the extreme values being included in the interval [222;350] (Table 2). Mean 6MWT values at admission tend to 260 m in women and 290 m in men. The women's sample contains much lower values than the men's (Figure 7a).



a) evaluation on admission b) predicted c) evaluation at discharge

Figure 7. Graphical distribution of the values obtained at 6MWT according to gender

The values obtained at 6MWT at discharge have an average of 397.3 m with a very small standard deviation (SD) of 54.21, the extreme values being included in the interval [324;493]. Mean values of 6MWT at discharge tend to 360 m in women and 425 m in men. The female sample contains lower values than the male sample (Figure 7c). Thus, following the application of the original cardiac rehabilitation program, the values obtained at 6MWT increased significantly. We notice that the graph in Figure 7b. (accepted predicted values) is very similar to the graph in Figure 7c. (values above the accepted predicted threshold are obtained), which means that the effect of applying the original cardiac rehabilitation program is a very strong one on the participants' results, *which have improved significantly*.

The T-test

In order to verify to what extent the original medical rehabilitation program had a positive effect on the patients, the admission and discharge values of several medical indicators were collected. The impact measurement of the difference between their means was calculated with the T-test for paired variables and Cohen's test, because our variables are

measured on a ratio scale and show an approximately normal distribution, as we observed in the descriptive statistics (Table 2). To apply the T-test, we started from the null hypothesis H0, which states that there are no statistically significant differences between the initial and final average values of our indicators. The aim is to confirm the alternative hypothesis H1 which states that these differences are statistically significant in order to be able to extrapolate the research hypotheses to the entire statistical population, provided that the sample is representative.

In our case the sample is too small, but this research represents an important step for future research.

Table 3. *Paired Samples T-test*

			statistic	df	p	Mean difference	SE difference		Effect Size
FCa	FCd	Student's t	2.82	9.00	0.020	6.10	2.163	Cohen's d	0.892
TASa	TASd	Student's t	3.36	9.00	0.008	17.40	5.182	Cohen's d	1.062
TADa	TADd	Student's t	6.54	9.00	< .001	12.50	1.910	Cohen's d	2.069
SpO2a	SpO2d	Student's t	-26.14	9.00	< .001	-6.10	0.233	Cohen's d	-8.267
VO2maxa	VO2maxd	Student's t	-13.93	9.00	< .001	-5.80	0.416	Cohen's d	-4.405
6MWTa	6MWTd	Student's t	-15.92	9.00	< .001	-121.80	7.649	Cohen's d	-5.036

Note. H_a $\mu_{\text{Measure 1 - Measure 2}} \neq 0$

The T-test value (2.82) for paired HR variables indicates that the difference between HRa (73.3) and HRd (67.2) is 6.10 and the standard error is 2.16. This difference is statistically significant because p=0.02 lower than the maximum accepted threshold (0.05), so we can extrapolate this hypothesis to the entire statistical population (Table 3). Cohen denotes a large effect (0.892) which means that *the effect of the original cardiac rehabilitation program is a very strong one on the participants' outcomes*, which improved significantly. Figure 8 shows the decrease in the average heart rate. Cohen d - effect size interpretation: A commonly used interpretation is to refer to effect sizes as small (d = 0.2), medium (d = 0.5), and large (d = 0.8) on the basis of the reference criteria suggested by Cohen (1988). However, these values are arbitrary and should not be rigidly interpreted (Thompson, 2007).

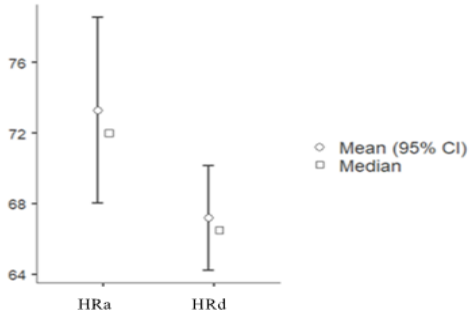


Figure 8. HRa (73.3) versus HRd (67.2)

The paired SBP T-test value (3.36) indicates in Figure 9 that the difference between SBPa (130) and SBPd (112.6) is 17.4 and the standard error is 5.18. This difference is statistically significant because p=0.008 lower than the maximum accepted threshold (0.05), so we can extrapolate this hypothesis to the entire statistical population (Table 3). Cohen denotes a very large effect (1.062) which means that *the effect of the original cardiac rehabilitation program is a very strong one on the participants' outcomes*, which improved significantly.

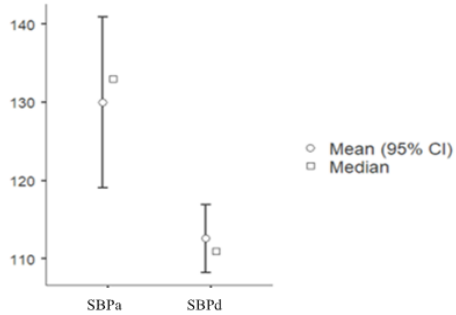


Figure 9. SBPa (130) versus SBPd (112.6)

The T-test value (6.54) for paired variables on DBP indicates in Figure 10 that the difference between DBPa (79.2) and DBPd (66.7) is 12.5 and the standard error is 1.91 (not very large). This difference is statistically significant because p<0.001 lower than the maximum accepted threshold (0.05), so we can extrapolate this hypothesis to the entire statistical

Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XXIV, ISSUE 2 Supplement, 2024, Romania
The journal is indexed in: ERIH PLUS, Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST, DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengage Learning, Cabell's Directories

population (Table 3). Cohen denotes a very large effect (2.069) which means that the *effect of the original cardiac rehabilitation program is a very strong one on the participants' outcomes*, which improved significantly.

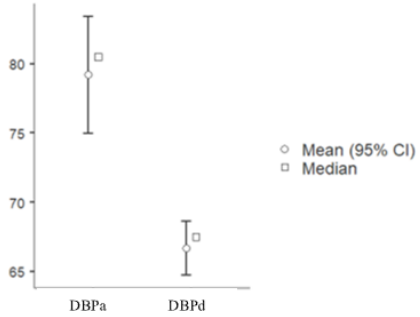


Figure 10. DBPa (79.2) versus DBPd (66.7)

The T-test value (-26.14) for paired variables on SpO_2 indicates in Figure 11 that the difference between SpO_2a (92.4) and SpO_2d (98.5) is -6.10 and the standard error SD is 0.233 (very small). This difference is statistically significant because p<0.001 lower than the maximum accepted threshold (0.05), so we can extrapolate this hypothesis to the entire statistical population (Table 3).

Cohen denotes a very large effect (-8.267) which means that the *effect of the original cardiac rehabilitation program is a very strong one on the participants' outcomes*, which improved significantly.

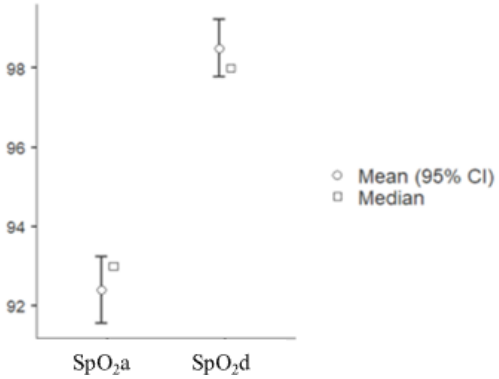


Figure 11. SpO_2a (92.4) versus SpO_2d (67.2)

The T-test value (-13.93) for paired variables on VO_2max indicates in Figure 12 that the difference between VO_2maxa (26.1) and VO_2maxd (31.9) is -5.8 and the standard error SD is 0.416 (quite small). This difference is statistically significant because p<0.001 lower than the maximum accepted threshold (0.05), so we can extrapolate this hypothesis to the entire statistical population (Table 3).

Cohen denotes a very large effect (-4.405) which means that the *effect of the original cardiac rehabilitation program is a very strong one on the participants' outcomes*, which improved significantly.

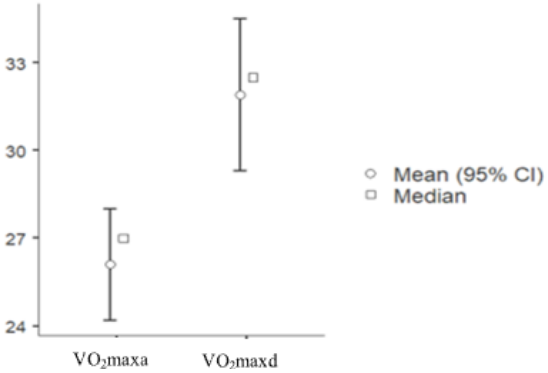


Figure 12. VO_2maxa (26.1) versus VO_2maxd (31.9)

The T-test value (-15.92) for paired variables regarding the distance covered in the 6-minute walk test 6MWT indicates in Figure 13 that the difference between 6MWTa (275.5) and 6MWTd (397.3) is -121.8 and the standard error is 7.64.

This difference is statistically significant because p<0.001 lower than the maximum accepted threshold (0.05), so we can extrapolate this hypothesis to the entire statistical population (Table 3).

Cohen denotes a very large effect (-5.036) which means that the *effect of the original cardiac rehabilitation program is a very strong one on the participants' outcomes*, which improved significantly.

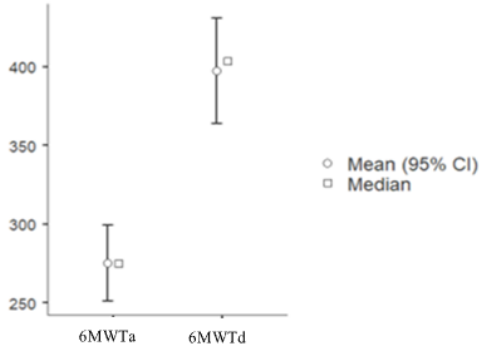


Figure 13. 6MWTa (275.5) versus 6MWTd (397.3)

Given that the alternative hypothesis H1 was confirmed for all six pairs of T-tests above, we can state that the *effect of the original cardiac rehabilitation program is a very strong one on the participants' outcomes*, which improved significantly.

Table 4. Shapiro-Wilk test

Normality Test (Shapiro-Wilk)				
			W	**P**
HRa	-	HRd	0.868	0.096
SBPa	-	SBPd	0.893	0.181
DBPa	-	DBPd	0.881	0.133
SpO_2a	-	SpO_2d	0.833	0.036
VO_2maxa	-	VO_2maxd	0.942	0.575
6MWTa	-	6MWTd	0.906	0.256

Note. A low p-value suggests a violation of the assumption of normality

The Saphiro-Wilk test takes values for all pairs of variables except oxygen saturation for which p=0.036 < 0.05. Thus, the condition of normal distribution of the SpO_2 variable was not met, so we must have reservations in extrapolating H1 for SpO_2.

All other variables meet the condition of normal distribution.

The correlation between the studied variables

From Table 5 it can be seen that age correlates strongly positively with SBPa (0.85), SBPd (0.75), weakly with DBPd (0.32) and moderately negatively with SpO2d (-0.53) and 6MWTa (-0.52). So, the older the age, the higher the SBP and DBP, the lower the SpO_2 and the distance traveled. From Table 5 it is also observed that DBP at discharge correlates weakly positively with SpO_2a (0.4), VO_2maxa (0.35), VO_2maxd (0.35) and with Gen (0.47), so DBP at discharge it is higher in men the higher the maximum oxygen consumption VO_2max at discharge. It is observed that VO_2maxd (0.90) and VO_2maxa (0.94) correlate strongly positively with gender, so men record higher VO_2max values.

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Table 5. Correlation between variables

	Age	HRa	HRd	SBPa	DBPa	SBPd	DBPd	SpO_2a	SpO_2d	VO_2maxa	VO_2maxd	Gen	6MWTa	Predicted	6MWTd
Age	1.00														
HRa	-0.19	1.00													
HRd	-0.12	0.60	1.00												
SBPa	0.85	-0.44	-0.12	1.00											
DBPa	0.75	-0.43	-0.08	0.79	1.00										
SBPd	0.29	-0.32	-0.01	0.37	0.48	1.00									
DBPd	0.32	-0.02	0.35	0.32	0.46	0.83	1.00								
SpO_2a	-0.30	-0.23	0.09	-0.15	0.18	0.20	0.40	1.00							
SpO_2d	-0.53	-0.23	0.12	-0.39	0.07	0.20	0.23	0.84	1.00						
VO2maxa	0.10	0.16	0.51	0.06	0.44	0.29	0.35	0.02	0.26	1.00					
VO2maxd	0.04	0.06	0.42	0.04	0.44	0.26	0.30	0.09	0.35	0.98	1.00				
Gen	0.29	0.13	0.53	0.17	0.53	0.29	0.47	0.10	0.18	0.94	0.90	1.00			
6MWTa	-0.52	0.38	0.25	-0.61	-0.18	-0.28	-0.14	0.26	0.43	0.55	0.59	0.48	1.00		
Predicție	-0.19	0.38	0.15	-0.36	0.08	-0.07	0.05	0.16	0.25	0.62	0.62	0.59	0.91	1.00	
6MWTd	-0.18	0.37	0.20	-0.33	0.11	-0.08	0.07	0.20	0.26	0.64	0.65	0.63	0.92	0.99	1

The legend: Green = strong positive correlation (R >0.7)
Yellow = average positive or negative correlation (0.5<R<0.7 or - 0.7<R<-0.5)
Red = small positive or negative correlation (0.3<R<0.5 or - 0.5<R<-0.3)

Distance covered at 6MWT at discharge correlates strongly positively with values obtained on this test at admission (0.92) and mean with Gender (0.63), VO_2maxd (0.65) and with VO_2maxa (0.64). So, patients obtain better/larger values on 6MWT at discharge the higher values they obtained on the same test at admission, and the higher VO_2max values. Males obtain better/larger results (Table 5).

Conclusions

For the main body functional parameters: heart rate (HR), systolic and diastolic blood pressure (BP), oxygen saturation (SpO_2) and maximal oxygen consumption (VO_2max), for the ten research participants, initial and final results were compared using the T-test.

Following statistical analysis of the results of the present study, statistically significant differences ($p < 0.05$) were found between the results recorded in 10 participants at baseline (admission) and at the final assessment (discharge) for the applied test - the 6 Minute Walk Test (6MWT). Using the paired variables T-test for distance covered in the 6MWT, it was shown that at the end of the study period, *patients improved their level of effort capacity*, achieving significantly better results compared to those recorded at baseline (when there was a reduced tolerance to physical effort).

In the case of measuring the distances covered by the patients during the 6MWT, values higher than the accepted predicted ones were obtained, which means that *the effect* of the application of the original cardiac rehabilitation program *is a very strong one on* the results of the participants, which improved significantly.

Statistical analysis for HR values identified a statistically significant difference between the results at baseline and at the end of the research period. The effect size indicator was r = 0.892 for HR values, which means that the *effect of the original cardiac rehabilitation programme is very strong on participants' outcomes*, which improved significantly (HR values decreased at the end of the research period). Regarding the SpO_2 values measured at the time of admission and those at the time of discharge, there are significant differences ($p<0.001$) after the application of the original cardiac rehabilitation program. The effect size indicator highlights a very strong effect of the original intervention on the SpO_2 values of the participants (values increasing significantly). Regarding the VO_2max measured at the time of admission of patients and the values at the final assessment (at the time of discharge), after the application of the original cardiac rehabilitation program there are statistically significant differences ($p<0.001$). In the case of this functional index (Vo_2max), the size of the *effect of the application of the original cardiac rehabilitation program is a strong one on the results of the patients* in the study (VO_2max values being significantly higher at the end).

The above findings validate the research hypothesis that the application of the original cardiac rehabilitation program leads to increased effort capacity and quality of life in patients with valve disease surgically corrected by minimally invasive techniques.

The methods and clinical data underlying cardiac rehabilitation will continue to evolve. We aim to continue, update and review studies of cardiac rehabilitation in patients with surgically corrected valvulopathies.

Authors contribution

All authors had equal contributions and accepted the final manuscript.

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