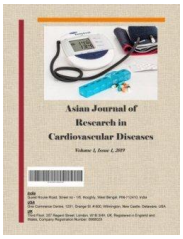

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Physical Retraining in Heart Failure: Evaluation of 30 Patients at the Abidjan Institute of Cardiology (Ivory Coast)

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Authors' contributions

This work was carried out in collaboration among all authors. Author KD conceived the draft of this study and wrote it. Authors GL, TM and AA collected the data for this study. Author KC read it and made corrections to this work. All authors read and approved the final manuscript.

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ABSTRACT

Background: Evaluation during heart failure (HF) rehabilitation helps identify the risk factors for poor adherence to physical exercise. Nevertheless, contradictions exist and few studies focused on the motivation in the pursuit of sports activity.
Materials and Methods: This was a retrospective cohort pilot study of 30 heart failure patients who underwent cardiac rehabilitation between January 2015 and January 2019 at the Abidjan Institute of Cardiology in Ivory Coast. The patients and their treating physicians were recontacted on average of 19 months after their rehabilitation to specify their therapeutic adherence as well as the short-term and long-term clinical and paraclinical benefits.
Results: Our study showed that there were clinical and paraclinical advantages in the short-term and long-term rehabilitation at the Abidjan Institute of Cardiology. However, only 44% of the participants pursued physical exercise after rehabilitation. Lack of endurance at the end of rehabilitation (p=0.049) and insufficient motivation (p=0.021) were related to poor adherence to physical activity.
Conclusion: The endurance at the end of rehabilitation and patient motivation seems to be related

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to the continuation of physical activity. The Observed Progress in Endurance (OPE) is a novel variable that has been proposed to identify the potential least observant or compliants patients.

Keywords: Heart failure; rehabilitation; motivation; endurance; long-term adherence.

1. INTRODUCTION

Numerous studies have demonstrated the short and long-term efficacy of rehabilitation in patients with heart failure; nevertheless, the pursuit of exercise is the key for long-term rehabilitation success to maintain the acquired benefits [1-7]. The patient's adherence or observance to physical exercise is under-documented and probably different from that observed in large cohorts of voluntary patients.

Despite the little knowledge on this observance, the European Society of Cardiology has identified it as the main obstacle to the widespread of physical exercise in heart failure [4]. Remarkably, while only 60% of eligible cardiac patients are referred to the rehabilitation center [4], adherence to physical exercise appears to be extremely low with 40% [8].

Wittmer et al. [7] have recently observed that the initial evaluation allows the identification of new risk factors for the future poor observance. They include low maximal aerobic power, high body mass index (BMI), smoking, isolation, and presence of diabetes [9]. All these objective factors of non-compliance or non-observance are found in the study of Marzolini et al [10]. However, there are some contradictions with Sanderson et al. [9] who have revealed that the presence of diabetes favours better compliance [9]. Similarly, Chien et al. [11] have shown that a low BMI is associated with poor compliance [11]. All these studies are of high quality. In contrast, the motivation theme is partially investigated. Tierney et al [12] have confirmed the effectiveness of some motivational methods within heart failure patients for the observance. Is motivation a variable explaining the link between poor observance and these findings, sometimes contradictory?

The European Society of cardiology, as explained in the treatment section, takes a position for both hypotheses [4]. Assuming that motivational factors are significantly culture-dependent, a French research study in this field remains relatively underdeveloped. Consequently, the French Society of Cardiology is planning a multicenter study on the Maintenance of Physical Activity after cardiac rehabilitation in France (EMAP study) [13].

The main objective of this study was double. First, the study was directed to determine whether there were clinical and/or paraclinical benefits in the short-term and long-term retraining program in patients with heart failure at the Abidjan Institute of Cardiology. Second, it aimed at determining if physical activity was continued and if not why, to describe the population at risk of not following the recommendations, mainly, physical activity for long-term rehabilitation for heart failure.

2. MATERIALS AND METHODS

This was a retrospective cohort pilot study including 30 patients who underwent cardiac rehabilitation between January 2015 and January 2019 at the Abidjan Institute of Cardiology (ICA). Prior to the course of rehabilitation, the patients included in the study had heart failure with LVEF ≤45% and completed a 20-day rehabilitation course at the ICA. Non-inclusion criteria consisted of the presence of respiratory failure and incomplete pre- and post-exercise stress test data. That "pilot" study did not require the prior calculation of the number of patients needed for the study. The studied variables were consisted of demographic factors (age, sex, socio-professional, and family status), cardiovascular risk factors, of other significant histories, of cardiovascular treatment, of pre- and post-cardiovascular rehabilitation items, such as metabolic panel, results of the 6-minute test, results of the Hospital Anxiety and Depression Scale (HADS) score [14], performance of the exercise stress test, and results of cardiac ultrasound.

The main categories of factors of poor therapeutic observance and the clinical and paraclinical markers of possible improvement or worsening were evaluated. The questionnaires were derived from the factors of non-observance or non-compliance described by the European Society of Cardiology [4].

Patients were contacted exclusively by telephone at the number listed on their medical file. After oral information, all patients were asked for authorization through a telephone call. Patients who did not respond to the calls were excluded or deceased. A questionnaire was designed for the treating physicians. The following values were compared before and after rehabilitation: BMI, metabolic panel results (total, HDL, and LDL cholesterol, triglycerides, glycemia), 6-minute test results (HR before and immediately after the test, and traveled distance), HADS score and sub-scores corresponding to anxiety and depression, LVEF on transthoracic echocardiography, exercise stress performance values: a peak of VO2 measured from the Kahalin formula, HR, power, and deadline at the first threshold and maximal effort. Note that we also used in our calculations endurance, which is the maximum power that can be maintained by a patient during a 30-minutes.

2.1 Statistical Analysis

Given the pilot nature of the study, non-parametric tests were only used in this study. The Wilcoxon test was used for before and after comparisons of continuous variables. The Fisher's exact test for binary variables and the Mann-Whitney test for continuous variables were utilized to separate the variables according to their presumed relationship to physical exercise.

The description of the subjective variables was done by giving the absolute number and the proportion of patients regarding each variable.

3. RESULTS

3.1 Description of the Study Population

3.1.1 Population of study

The study population consisted of 30 patients selected among 380 people. The mean age was 57 years old and 17% were women (Table 1).

3.1.2 Demographic factors of patients

Patients enrolled in the study were followed according to the pattern described in Table 7.

The mean deadline for the follow-up questionnaire was 18.9 months with a median deadline of 10 months (Fig. 1).

3.1.3 Demographic factors of physicians

All the 28 treating physicians included in the study worked in the city. 14% of them were women. They had an average of 6 years of practice (Table 4).

3.1.4 Participation rate in follow-up questionnaires

Patients: Of 30 patients included in the study, 2 died, 1 refused to participate in the study, and 2 others could not be reached. A total of 25 patients participated into the study.

Physicians: Among 28 treating physicians, 5 did not respond. Among the respondents, 2 lost the contact with their patients, and 1 had no data on a patient who had died several months earlier. A total of 22 treating physicians participated into the study.

Table 1. Population of the study

Year	Number of stays	Mean age	Women (%)
2018	136	55.70	17.47
2017	78	57.24	20.11
2016	77	58.6	18.20
2015	89	58.8	12.40
Total	380	57.33	16.97

Table 2. Recruitment of 30 patients

	2019	2018	2017	2016	2015
Number of recruited patients	1	18	2	0	9

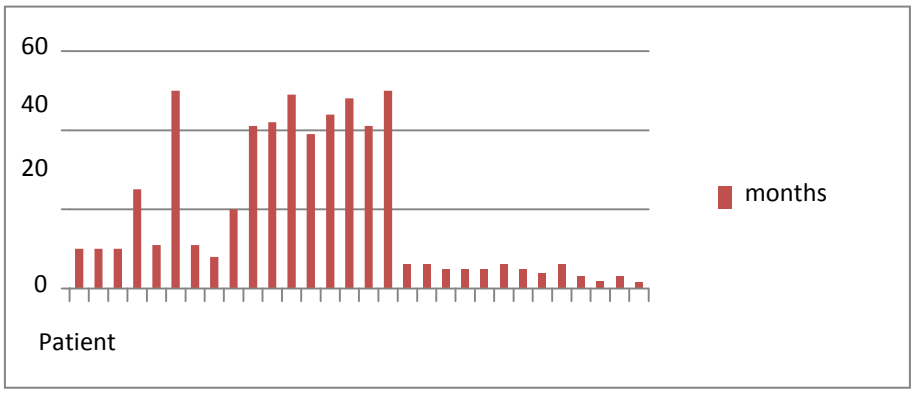

Fig. 1. Post-rehabilitation recruitment deadlines

Table 3. Demographic factors of 30 patients

Criteria		Number (%)*
Mean age at réadaptation		55.63
Proportion of femmes		20 %
Socioprofessionnel category	Public servants	21 (70)
	Private sector workers	9 (30)
Family status	Married	21 (70)
	Single	9 (30)
	Low house	24 (80)
Accommodationt	Apartment	5 (16.7)
	Family in the village	1 (3.3)
	Tobacco/smoking	13 (43.3)
	Obesity	16 (26.7)
	High blood pressure	22 (73.3)
Cardiovascular risk factors	Diabetes	11 (36.7)
	Sédentarity lifestyle	15 (50)
	Alcohol	4 (13.3)
	Dyslipidemia	24 (80)
	Stress	18 (60)
	Heredity	12 (40)
History of atrial fibrillation		3 (10)
Revascularisation	Stenting	14 (46.7)
Implantation of a pacemaker	Pacemaker	1 (3.3)
	Ischemic	23 (76.7)
	Monotruncular	13 (43.3)
	Bitruncular	6 (20)
Etiologies	tritruncular	3 (10)
	Missing data	3 (10)
	Dilated cardiomyopathy	5 (16.7)
	Valvular	2 (6.7)
	Béta-blockers	28 (93.3)
	ACE inhibitors	23 (76.7)
	Diuretics	18 (60)
	ARA-II	6 (20)
Traitments	Anticoagulants	4 (13.3)
	Antiplatelet agents	25 (83.3)
	Fibrates	1 (3.3)
	Statin	24 (80)
	Current inhibitor If	3 (10)
	Aldosterone antagonist	16 (26.7)

** With the exception of age and proportion of women*

Table 4. Characteristics of 28 treating physicians

Total number	Number of women (%)	Urban practive site (%)	Years of practice after the thesis (mean)
28	4 (14%)	28 (100%)	6

Table 5. Before and after results of 30 files

		Mean		
	Input		Ouput	Wilcoxon's p
Metabolic parameters	Total cholesterol (g)	1.741	1.545	0.01*
	HDL cholesterol (g)	0.428	0.422	0.82
	LDL cholesterol (g)	1.012	0.854	0.02*
	Triglycerides (g)	1.529	1.37	0.41
	Fasting glycemia (g)	1.172	1.24	1
	BMI (kg/m2)	31.097	30.787	0.016*
6-minute walk test	Distance (meters)	493.167	545.667	0.0001*
	HR - T0 (per min)	73.567	72.467	0.53
	HR- T6 (per min)	96.267	98.967	0.75
Hospital Anxiety and Depression Scale	Anxiety	8.316	5.684	0.001*
	Depression	5.632	4.895	0.26
1st ventilatory threshold	Total	13.421	10.684	0.01*
	Endurance (watts)	48.438	52.5	0.19
	Exercice duration (min)	2.433	3.854	0.0001*
	Power (watts)	52.833	69.7667	0.00002*
	HR (pear minute)	97.333	94.767	0.62
	VO2 (ml/kg/min)	10.74	12.877	0.0006*
Maximum capacities	Exercice duration (min)	5.533	7.334	0.00001*
	Power (watts)	84.433	106.433	0.000003*
	HR (par min)	114.9	117.867	0.33
	VO2 (ml/kg/min)	14.902	17.975	0.00006*
Echography	LVEF (%)	33.905	39.429	0.005*

HDL- High Density Lipoprotein, LDL- Low Density Lipoprotein,
BMI-Body Mass Index,
HR- Heart Rate,
Peak of VO2- Oxygen consumption, Kahalin formula,
FEVG- Left Ventricular Ejection Fraction

** Significant difference according to the Wilcoxon test*

3.2 Results of the Study

3.2.1 Study of medical files

To study the impact of short-term rehabilitation, a before and after study was performed (Table 5).

3.2.2 Study of follow-up questionnaires

The Table 11 described the responses to the patient questionnaires for the binary variables. The same study was done in the Table 13 by treating physicians. The Table 14 described the continuous variables for both populations.

Binary variables of patient questionnaires:

Table 6. Binary variables questionnaire 25 patients

Simplified statements	Number of patients in agreement (%)
Registration to a sports club	3 (15)
Mortality	2 (8)
Rehospitalizations for cardiovascular causes after rehabilitation	7 (28)
Treatment omission	5 (20)
Improvement of quality of life since rehabilitation	21 (84)
Daily physical exercise – essential	17 (68)
Less dyspnea since rehabilitation	18 (72)
Better knowledge of the disease since rehabilitation	23 (92)
Less anxiety and depression since rehabilitation	15 (60)
Stimulating family members to exercise	15 (60)
Good memory of rehabilitation at Abidjan Institute of Cardiology	25 (100)
Lack of resources - cause of inefficient exercise	9 (36)
Good explanation to continue exercises at home or at the ICA	23 (92)
Confidence in treating physician	25 (100)
Treating physician encouraging physical exercise	17 (68)
Good integration of physical exercises in the lifestyle	18 (72)
Side effects of physical excercises other than shortness of breath or fatigue	2 (8)
Motivational problems to do physical exercises	18 (72)
Patients reporting daily 45 minutes or more physical activity	11 (44)

Binary variables of physician questionnaires:

Table 7. Binary variables of 22 physician questionnaires

Simplified statements	Number of physicians agreeing or responding positively (%)
Patient observing the treatment	20 (91)
Improvement of life quality after rehabilitation at ICA	22 (100)
Decrease of dyspnea after your patient's rehabilitation	19 (86)
Better patient knowledge of the disease after rehabilitation	16 (73)
Improvement of psychological condition (anxiety/depression) after rehabilitation	15 (68)
Rehabilitation is an essential treatment in HF	22 (100)
Cardiac rehabilitation is an effective treatment	23 (100)
Except obesity, correction of cardiovascular risk factors	13 (59)
Patient counselling in favor of physical exercise	18 (82)

Continuous variables of both physician and patient questionnaires:

Table 8. Continuous variables of physician and patient questionnaires

Variables	Mean*
NYHA before rehabilitation according to TP	3
NYHA after rehabilitation according to TP	2
Last LVEF	37.8
Last HDL cholesterol	0.37
Last LDL cholesterol	0.83
Last glycemia level	1.39
Current BMI	32.1

Variables	Mean*
Last systolic blood pressure within TP (mm Hg)	122.5
Last diastolic blood pressure within TP (mm Hg)	70.8
Exercise time including walking reported by patient	0.738
* Except for the NYHA score where the median is used	
TP-Treating physician, mm Hg – millimeters of mercury	

Comparison of files and follow-up questionnaires:

Table 9. Comparison of patient files

At the release of mean rehabilitation		Current mean	p-value
NYHA score	3	2	0.0005*
LVEF	39.4	37.8	0.57
HDL cholesterol	0.42	0.37	0.17
LDL cholestérol	0.85	0.83	0.57
Glycemia	1.24	1.39	0.031*

** Statistically significant according to Wilcoxon test; for NYHA, the score was reported during the period before rehabilitation ¤ Median for NYHA score*

3.3 Variables Related to Non-Observance

Non-observance or non-compliance is defined as insufficient physical exercise according to the recommendations. In this study, a daily activity of less than 45 minutes was considered insufficient. In the Tables 12-14, a relationship was examined between adequate physical activity and different variables.

3.4 From the Study of the Files

3.4.1 Continous variables

Table 10. Variables of files related to physical exercise

		Sports		
		Yes	No	
	Exit variables *			p-value**
	Glycemia	1.65	1.07	0.628
Metabolic variables	Total cholesterol	1.62	1.57	0.713
	LDL cholesterol	0.84	0.915	0.792
	HDL cholesterol	0.36	0.46	0.409
	BMI	32.9	29.85	0.261
	Distance at 6 minutes	582.73	550.71	0.762
6-minute Test	HR T0	75.91	68.79	0.124
	HR T6	106.45	94.786	0.162
	Endurance	64.28	43.33	0.049¤
	Anxiety	6.78	4.7	0.303
HADS score	Depression	5.67	4.2	0.284
	Total	12.67	8.9	0.129
	Power	77.55	67	0.459
First threshold	HR	94.73	95.93	0.602
	Deadline	3.89	4.1	0.825
	Peak of VO2	13.73	12.96	0.742
	Power	121.45	98.36	0.17
Maximum capacity	HR	122.72	116.64	0.38
	Deadline	7.32	7.59	0.763
	VO2	19.37	17.71	0.805
	LVEF	36.36	36.64	0.92

Sports			
	Yes	No	
Exit variables *			p-value**
HR – Heart Rate, BMI – Body Mass Index, Mean values at the end of rehabilitation, According to Mann and Whitney test, ¤ Significant test			

3.4.2 Binary variables

Table 11. Variables of files related to physical exercice

Physical exercices			
Statements	**Yes**	**No**	**p-value**
Male	9	11	1
Assisted living	9	10	0.661
Being on leave	9	9	0.407
Living in a house	9	10	0.661
Sinus rhythm	9	14	0.183
Ischemic etiology	8	12	0.623
Diabetes	4	5	1
Heredity	4	7	0.689
Sedentary lifestyle	4	9	0.238
High Blood Pressure	8	11	1
Obesity	7	7	0.689
Dyslipidemia	9	11	1
Alcohol	2	2	1
Stress	8	8	0.676
Smoking	3	8	0.227
Pacemaker	2	3	1

** Significant result according to Fisher's exact test*

From follow-up questionnaires of patients:

Table 12. Variables of the questionnaires related to physical exercise

Physical exercices			
Simplified statements	**Yes**	**No**	**p-value**
Improvement of the quality of life	10	11	0.604
Daily physical exercise – essential	9	8	0.233
Less dyspnea	8	10	1
Better knowledge of the disease	10	13	1
Less anxiety and depression	7	8	1
Registration at the Heart and Health Clubs	2	1	0.564
Rehospitalizations	2	5	0.406
Traitements omissions	2	3	0.825
Good memory of rehabilitation	11	14	1
Lack of resources	2	7	0.207
Better explanation to continue the exercises	10	13	1
Confidence in the treating physician	11	14	1
A supportive treating physician	9	8	0.233
Good integration of exercise into lifestyle	9	9	1
Side effects of physical activities	2	0	0.18
Motivational problems	5	13	0.021
Significant result			

From questionnaires of physicians:

Table 13. Variables of questionnaires related to physical exercise

Physical exercices			
Simplified statements	**Yes**	**No**	**P- value**
Patient observing the treatment	7	11	0.42
Improvement of life quality after rehabilitation	9	11	1
Decrease of dyspnea after rehabilitation	8	9	1
Better patient knowledge of the disease after rehabilitation	6	9	0.44
Improvement of psychological condition after rehabilitation	6	8	1
Rehabilitation is an essential treatment in HF	9	11	1
Cardiac rehabilitation is an effective treatment	9	11	1
Except obesity, correction of cardiovascular risk factors	4	8	1
Patient counselling in favor of physical exercise	8	9	1

Using Fisher's exact test

Continuous variables from questionnaires of patients and physicians:

Table 14. Continuous variables related to physical excercise

Sports			
Variables (mean)	Yes	No	p-value
Deadline in months	12.86	15.79	0.526
Age at rehabilitation	52.27	56.36	0.546
Age on questionnaire	53.18	57.64	0.458
LVEF*	44.67	33.375	0.22
HDL cholestérol*	0.35	0.38	0.65
LDL cholestérol *	0.88	0.82	0.54
Glycemia*	1.48	1.2	0.94
BMI*	34.33	29.98	0.26
Systolic pression*	124.5	121	0.6
Diastolic pression*	71	71	0.88

** Last known value, ** According to Mann and Whitney test, BMI - Body Mass Index*
Pressure in millimeters of mercury

3.5 Open Questions

Patients and physicians were asked about actions to be taken so that patients undergoing cardiac rehabilitation would continue their rehabilitation as recommended. In addition, physicians, who did not advise patients for physical exercise after rehabilitation, were asked about the reasons for this action.

3.6 Patient Questionnaire

Among 25 patients who answered this question, 6 did not want any change in the system and exercised for more than 45 minutes a day.; 4 patients had no opinion on this question. For the other answers, the semantic analysis and verbatim highlighted 2 groups of answers. 14 of these responses were about the post-rehabilitation period while 4 responses were about the rehabilitation period.

First, review the lexical items associated with the post-rehabilitation period:

- the first problem is that of "motivation" (5 citations) and "stimulation" (1 reference);
- this "motivation" seems to be strongly linked to a notion of "follow-up" (2 references and 11 synonyms);
- another promoter of "motivation" seems to be the "group" (4 uses and 4 other synonyms) and is opposed to "isolation" used only once but with a negative connotation;
- other proposals are interested in the "Heart and Health" association (4 citations) and in particular, propose to improve its "accessibility" (3 references).

· Only one proposal offers financial assistance.

Second, listing the themes concerning the rehabilitation period:

· It is mostly about the modalities of the internship. The first modality seems to be the duration of the internship (2 citations), the second being the frequency (1 citation) and the accessibility (1 mention).

3.7 Questionnaires of Physicians

Out of 22 responses collected, 3 had no opinion on this question. Unlike the patients, the general physician only considered the post-rehabilitation period in the other responses:

§ The main theme was undoubted "motivation" and cited 6 times as well as its synonyms mentioned 4 times;
§ Similarly to the patient questionnaire, for the treating physicians, this "motivation" is linked to "follow-up" (5 references) and to the "rehabilitation center" (2 citations).
§ Some responses provide specific indications:

- encouragement of enjoyable activities,
- limitation of television watching,
- limitation of car travel,
- Reduction of fees of clubs and training of specialized "coaches''

Regarding the non-support for physical exercise, 4 (18%) physicians did not advise patients for physical exercise. The reasons were mentioned in cases as followed:

ü 1 active patient active (he is working);
ü 2 patients were unable to exercise because of their clinical conditions, such as severe dyspnea and disabling back pain.

4. DISCUSSION

4.1 Short-Term Results of Rehabilitation in Heart Failure

The recruitment of women was 20% in this study, which is comparable to the 28% found in the HF-ACTION Study. The COACH study showed a higher percentage of women with 38% (261). Despite some variability in proportions, women appear to be less represented than men in the rehabilitated heart failure population.

The pre and post-rehabilitation study showed several significant improvements in all categories of variables.

First, metabolic status improved with decreases in LDL cholesterol, total cholesterol (p=0.02; p=0.01, respectively) and BMI (p=0.016).

These changes appeared to be more due to the rehabilitation program than to drug management. Similarly, the walking distance was significantly increased (p=0.0001).

Exercise test values: exercise duration, power, and VO2 were increased at first and maximum threshold (p<0.001). These results are comparable to those of large cohort studies [15].

Thereafter, LVEF was also significantly improved (p=0.005). This result is not described elsewhere and is likely to be a bias. Indeed, in large studies, no improvement in LVEF was shown in the short term, although an improvement may be observed in the long term [16]. This improvement of LVEF may be related to our population with almost exclusively ischemic heart disease managed shortly after an acute episode. The improvement of LVEF may be related to a natural evolution of heart failure on ischemic heart disease after an acute episode (reversion of myocardial sideration, the effect of acute treatment, etc.).

Finally, the patient's psychological state also seemed to improve (p=0.01). This result corroborates with that of Blumenthal et al. which show an improvement in the anxiety-depressive state [17].

This current picture of the results obtained in the rehabilitation of heart failure at the Wattrelos site is similar to the results published in numerous studies. This is reassuring for the validation of the established protocols, even if they still need to be improved. However, it is necessary to verify whether these effects persist, and this is the goal of our work detailed in the following chapter.

4.2 Long-Term Study of Cardiac Rehabilitation

In our series, the follow-up shows an 8% of mortality rate at 19 months and 28% of rehospitalization for cardiovascular causes. In the Framingham Heart and the Hillingdon Heart Failure Studies, the mortality rate at one and five years after the diagnosis of heart failure was 30% and 65%, respectively. In the Rotterdam

Study, the mortality rate was lower with 11%, 21%, and 41% at one, two, and five years, respectively [18]. The mortality rate was 28% in the Coach Study, in which 35% of patients were rehospitalized at least once over 18 months for a cardiovascular cause [19]. In our study, the mortality rates are lower than those of the literature data. These differences in the mortality rate could be due to the recruitment of relatively less severe patients in our study than in the other studies. On the other hand, our rehospitalization rate is quite comparable, and we find the usual evolution and follow-up of a population of heart failure patients.

Somewhat surprised by such variable findings more or less old studies, we have decided to include some data from large, rigorous, and landmark studies in the treatment of heart failure: in SOLVD-T, the mortality with enalapril was 11.2% per 100 patient-years; in the CHARM Study, with candesartan, the mortality was 8.2 per 100 patient-years; in the PARADIGM-HF study, with LCZ696, the mortality was 6 per 100 patient-years [20].

Certainly, we cannot compare our 30-patient study with studies involving numbers of more than 1000 patients: SOLVD-T (1285 patients on enalapril), CHARM (1013 patients on candesartan). Nevertheless, it is valuable to note that our death rate at 18 months is within the range of these studies.

On the other hand, our annual rehospitalization rate for cardiovascular causes was higher with 18% compared with 10.9 percent per year in SOLVD-T on enalapril, 8.6 percent per year in CHARM on candesartan, and 6.2 percent per year in PARADIGM-HF. This rehospitalization frequency is striking. Patients are likely more compliant with the close monitoring in the rigorous and well-followed studies, and thus, may explain a lower rehospitalization rate.

More than half of the patients reported an improvement in quality of life (84%), dyspnea (72%), and knowledge of heart failure (92%) after rehabilitation. These results are considered in agreement with those of the literature data [21-22].

When studying the questionnaire of medical workers, a trend quite similar to that of the patient questionnaire was found. In particular, the majority of physicians observed improvements in dyspnea (86%), knowledge of the disease (73%), and quality of life (100%) of their patients after rehabilitation. It is interesting to consider that the assessment made by the treating physician of his patient corresponds well to the patient's feeling; the treating physician remains the closest person to the patient, and he is the one who probably has the most precise vision of the regular evolution of this chronic disease.

For the evaluation of observance, the treating physician undoubtedly overestimates the observance of his patients. Thus, 91% of the doctors stated that their patients were observant, and this did not correspond exactly to real observation. Twenty percent of patients had forgotten their medication in our study. This result is even slightly lower than the estimated 30-40% non-observance rate observed in heart failure [23,24]. Therefore, the observance is a major problem in heart failure as in all chronic diseases.

Sixty eight percent of the respondents thought that physical exercise was essential, but only 15% of them were enrolled in a sports club. Through the questionnaire, only 44% seemed to maintain regular physical activity. In the literature, the data are worse: 30% of patients adhered to physical exercise at one year in the HF-Action study [19] and 39% in the COACH study [25].

In this analysis, the only variable that seemed to deteriorate in the post-rehabilitation period was glycemia ($p=0.031$), the other variables remained at the same level. However, the post-rehabilitation increase level of glycemia showed that physical activity was reduced. Other studies have revealed an improvement in metabolic markers at 6 months [26]. We did not find any research study investigating glycemic levels at a distance from rehabilitation. This change in the glycemic status of our study population indicates the difficulty of maintaining regular physical activity and optimal observance.

How can we identify the heart failure patients who will be the least active and the least compliant after their rehabilitation passages?

We tried to identify the predictive parameters of this potentially negative situation. Here are our results.

4.3 New Insights Provided by Our Study

In our study, patients with stamina and motivation after rehabilitation are more compliant

with physical exercises at a distance from the rehabilitation. Motivation is a variable whose importance for the continuation of physical exercise has been recognized in several studies [4,10]. The motivation is related to regular follow-up, group work, and pleasure or leisure-linked activities. These relationships were found in several studies [4,8,15] where some of them even highlight the interest of "remotivation" at six months [18]. However, no guidelines have yet been developed by scholar societies [1,2,27,28].

Many items, regarding the motivation and particularly its genesis, are still not investigated [4].

In the methodology, we explained how nurses and doctors determined the endurance of each patient. We recall it here because this data is important for the discussion. The patient is offered an increased workload and work power on the cycle ergometer for a 30-minute effort duration. The patients who regularly manage to increase their work power during the 4 weeks of rehabilitation were considered enduring.

In our study, the endurance at the end of rehabilitation, was consistent with the power that the patient managed to maintain. It was the result of a progression observed during the whole rehabilitation. It resulted from the sum of an effort performance and motivation of the patient to progress. This is a new concept that is still not developed by current studies. For us, it correlates with a heart failure patient who

"can" more and "wants" more. This variable could not be identified as endurance but rather the Observed Progress in Endurance (OPE).

In our study, the continuation of physical exercise at home does not seem to be linked to effort performances at the end of the rehabilitation, but rather to the OPE. Interestingly, the performance acquired during a rehabilitation session can be rapidly lost during a sedentary behavior of less than one month [29-32].

Some training modalities already identified are more preferable to others. So, could it be that a better OPE with other training modalities, especially with intermittent or combined endurance and resistance training?

Adherence was a major problem in heart failure as described in the introduction; however, motivation is only addressed by some studies. When motivation is discussed, its apprehension is difficult. Our study proposes a new method to approach motivation and quantify it. This could be a process for assessing motivational methods.

In the other words, unmotivated and less enduring patients would need a reinforced follow-up associated with group work at the end of a rehabilitation period. The follow-up will ideally be a direct follow-up by connected devices, measuring physical activity. Indeed, these devices are accessible nowadays because of their abundance, their easy use, and their cheap prices [27-28]. French products, such as connected T-shirts, have been developed to be perfectly adapted to professional or amateur sports activity [29-32]. Moreover, French expertise has already demonstrated very promising and economically interesting results for remote monitoring of automatic implantable defibrillators [33,34]. These tools will allow attending physicians and cardiologists to supervise the activity of their heart failure patients equipped with pacemakers for cardiac resynchronisation therapy (CRT) and defibrillators with a single click in the future.

Moreover, patients should be advised to practice a physical activity that they enjoy. It will be necessary to favor moderate intramural physical activities without any competitive spirit after a personalized assessment [35].

In Europe, these physical activities are gymnastics, cycling, and running, which are ideally practiced in groups. In Asia, it may be efficient activities, such as tai-chi, qi-gong, etc; however, dancing remains the physical activity of choice.

As a result, the patient can find a preferred physical activity that he will continuously perform.

For years, doctors involved in cardiac rehabilitation would like to prove the effectiveness of rehabilitation in this field. The studies are sometimes contradictory and the results were not satisfactory at 2 years in the HF-ACTION study. Undoubtedly, the loss of effectiveness resulted from a lack of observance.

Objectively, the physician should fight against the relapse to a sedentary lifestyle as he fights against intra-stent restenosis.

Certainly, we will wait for the results of the French multicenter EMAP study, which will provide valuable information on the maintenance of physical activity in heart failure.

Finally, we must remain modest because physical activity and sport in healthy adults are already reduced: more than 50% of inactive people in the study of Wen CP et al. [36] and more than 30% according to the WHO [37].

5. CONCLUSION

Our study shows that there are clinical and paraclinical benefits in the short-term rehabilitation and at a distance from the rehabilitation.

Only 44% of the participants have continued to exercise significantly at the distance of the rehabilitation.

Endurance at the end of rehabilitation and patient motivation seems to be the only variables related to the continuation of physical activity. This study highlights a new variable called the observed progress in endurance to identify the patients who will be the least observant or compliant.

It would seem that patients who are not motivated and have little stamina at the end of a rehabilitation period would require a close follow-up along with group work and practice of physical activity that they like.

Further studies are needed to confirm and clarify these findings.

CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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