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ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

Effect of complex cardiac rehabilitation on physical activity and quality of life during long-term follow-up after surgical correction of congenital heart disease

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Abstract

Background: Comprehensive cardiac rehabilitation (CCR) is an important element of the comprehensive management of grown-up congenital heart disease (GUCH) patients after surgical correction of congenital heart disease (CHD) but access to this treatment is still limited. We still lack Polish guidelines on CCR, including controlled training in young adults several years after surgical correction of CHD.

Aim: To assess the effect of a CCR program on physical capacity, exercise tolerance, quality of life, and severity of depressive symptoms in GUCH patients long-term after surgical correction of CHD.

Methods: We studied 57 CHD patients (30 females, 27 males, mean age 23 ± 3.4 years) at least 12 months after surgical correction of a ventricular septal defect (VSD) or ostium secundum atrial septal defect (ASD II). All patients were offered a CCR program, and 31 of them participated (rehabilitation group [Reh]) and 26 refused (non-rehabilitated group [NReh]). All patients underwent baseline cardiopulmonary exercise testing (CPET) using a cycloergometer and a ramp protocol with an initial load of 20 W followed by 10 W load increments per minute. Psychological evaluation included the Beck Depression Inventory (BDI) and the Euro QoL 5D questionnaire to evaluate quality of life. Patients were reassessed 30 days after the initial evaluation using the same investigations.

Results: During CPET, all patients reached peak exercise intensity at the level of 15–17 in the Borg scale without complications. Resting HR was lower in the Reh group (74 ± 8 bpm) compared to the NReh group (81 ± 14 bpm). During CPET, patients in the Reh group reached significantly higher peak HR and percent maximum HR. Workload increased nonsignificantly (144 W vs. 124 W, $p = 0.121$), while duration of exercise and peak oxygen consumption was significantly longer in the Reh group compared to the NReh group (14 min vs. 11 min, $p = 0.001$; and 27.5 mL/kg/min vs. 23 mL/kg/min, $p = 0.003$, respectively). Patients in the NReh group showed non significantly higher severity of depressive symptoms compared to the Reh group, as evaluated using BDI at 30 days (mean score 4.8 vs. 2.2, respectively, $p = 0.59$). In contrast, subjectively and objectively rated quality of life was significantly higher in the Reh group compared to the NReh (score 89 vs. 74.4, $p < 0.01$; and 94 vs. 83, $p < 0.01$, respectively).

Conclusions: Implementation of a CCR program improves physical capacity, exercise tolerance, and quality of life and reduces depressive symptoms in patients late after surgical correction of CHD. Introduction of such programs seems reasonable as a supplement to the holistic care for GUCH patients.

Key words: grown-up patients with congenital heart disease, GUCH, cardiac rehabilitation, physical capacity, quality of life

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INTRODUCTION

Advances in perinatology, cardiac surgery, and paediatric cardiology have resulted in a steady increase in the number of grown-up congenital heart disease (GUCH) patients [1]. Modern therapeutic strategies have led to decreased early and late postoperative mortality and increased survival among patients with congenital heart disease (CHD) [2]. Evaluation of long-term results of surgical treatment of CHD should be based not only on the results of conventional diagnostic testing and patient survival but also on evaluation of physical capacity, exercise tolerance, and quality of life in this patient group.

An important aspect of managing adult patients after cardiac surgery is comprehensive cardiac rehabilitation (CCR) which has a proven effect on exercise tolerance and quality of life [3]. A wide discrepancy exists between high quality of cardiological and cardiac surgical care in CHD patients and actual lack of CCR, particularly in regard to late rehabilitation. Until now, rehabilitation in patients with CHD in Poland was mostly limited to the early postoperative period.

There are few reports in the Polish literature regarding exercise capacity in children [4, 5] and patients with CHD [6]. In addition, we still lack Polish guidelines on CCR, including controlled training in young adults several years after surgical correction of CHD. However, there is appreciation of a need to refer and include such patients in comprehensive late rehabilitation programs by offering multifaceted help, often extending beyond purely medical issues [7].

The aim of the study was to assess the effect of a CCR program on physical capacity, exercise tolerance, quality of life, and severity of depressive symptoms in GUCH patients long-term after surgical correction of CHD.

METHODS

Study population

The study was performed in the Department of Rehabilitation at the Medical University of Gdansk in 2007–2009, and the results were subject of a comprehensive analysis. We invited consecutive patients presenting for a follow-up visit to the CHD clinic at the Department of Paediatric Cardiology who fulfilled the inclusion criteria and gave their informed consent for participation in the study. Inclusion criteria included the clinical diagnosis (previous cardiac surgery via median sternotomy due to an intracardiac shunt lesion, i.e., ventricular septal defect [VSD] or ostium secundum atrial septal defect [ASD II]), time since cardiac surgery more than 12 months, age more than 18 years, and written informed consent for participation in the study. Exclusion criteria include active inflammatory disease, life-threatening arrhythmia, musculoskeletal system dysfunction precluding planned rehabilitation, other concomitant congenital or acquired cardiac defect, significant worsening of the clinical status of the patient within the last month, acute cardiac or neurological event within last 6 months, positive exercise test result, lack of patient consent, and psychiatric problems precluding adequate cooperation.

All patients were offered participation in a CCR program. Twenty-six patients refused to participate (non-rehabilitated group [NReh]), and 31 patients (17 women, 14 men) took part in a CCR program (rehabilitated group [Reh]). Patients in the NReh group received one-time advice regarding benefits of controlled exercise and the role of appropriate lifestyle. Reasons for patient refusal to participate in a CCR program included lack of time due to work or study, large distance from the place of residence to the Department of Rehabilitation, and prohibitively high transportation costs.

The study group included 30 patients following VSD correction and 27 patients following ASD II correction. Resting electrocardiogram (ECG) showed right bundle branch block in 15 patients, premature ventricular beats in 4 patients, and premature supraventricular beats in 2 patients.

Patients selected for the CCR program underwent initial medical evaluation including history and physical examination, and echocardiography. All patients underwent baseline cardiopulmonary exercise testing (CPET) using a cycloergometer and the CORTEX Meta-Soft system. A ramp protocol with an initial load of 20 W followed by 10 W load increments per minute was used. CPET was limited by severe perceived fatigue and standard indications for termination of the exercise test. Psychological evaluation included the Beck Depression Inventory (BDI) and the Euro QoL 5D questionnaire to evaluate quality of life [8, 9]. Patients were reassessed 30 days after the initial evaluation using the same investigations. We evaluated the following parameters: resting heart rate (HR), peak HR, duration of exercise, load in Watts, peak oxygen consumption (VO_2), quality of life, and severity of depressive symptoms.

Comprehensive cardiac rehabilitation program

The CCR program lasted 4 weeks and was based on the adult CCR guidelines [3, 6]. It included daily kinesiotherapy, psychological intervention, and education. Exercise rehabilitation included a 30-min cycloergometer training and general physical exercise training with elements of Nordic walking. The intensity of exercise was determined using the Karvonen formula: training HR = resting HR + 60–80% of HR reserve (defined as peak HR – resting HR). Active free exercises, exercises with instruments, and active resistance exercises were performed during gym classes. Coordination, relaxation, strengthening, and stretching exercises were used, with elements of aerobic to increase attractiveness of exercise. Breathing exercises were used to strengthen respiratory muscles and teach proper breathing both during exercise and other situations that require improved ventilation, such as dyspnoea and fatigue. Resistance exercises were performed using an exercise bench, with maximum load of up to 20 kg, up to 4 series of 15 repetitions, 2–3 times a week.

Table 1. General characteristics of the study population

Variable	Reh (n = 31)			NReh (n = 26)			P
	Mean	SD	Range	Mean	SD	Range	
Age [years]	23	3.4	19–29	24.5	4.8	18–36	0.42
Body mass [kg]	60.5	7.9	46–78	64	12.4	44–98	0.373
Body mass index	21.5	2	18–27	22.4	3.7	18–36	0.701
HRrest	80	11	64–103	81	14.2	47–98	0.575
SBP [mm Hg]	130	11	110–150	126	15	110–170	0.166
DBP [mm Hg]	78	6	70–90	79	10	55–100	0.521

Reh — rehabilitated group; NReh — non-rehabilitated group; SD — standard deviation; HRrest — resting heart rate; SBP — resting systolic blood pressure; DBP — resting diastolic blood pressure

Table 2. Baseline cardiopulmonary exercise testing results in the rehabilitated (Reh) and non-rehabilitated (NReh) group

Variable	Reh (n = 31)			NReh (n = 26)			P
	Mean	SD	Range	Mean	SD	Range	
HRpeak	143	18	106–167	148	25	87–200	0.374
%HRmax	73	9.3	54–86.5	76	12.3	45–99.5	0.262
Workload [W]	118	24.7	72.167	122.5	36	52–184	0.586
MET	6.7	1	4.8–9	6.9	1.7	2.5–9.4	0.791
VO_2peak	23.5	3.4	17–31	23	6	9–33	0.736
Duration of exercise [min]	10.9	2.3	6–16.5	11	3.8	4.3–19	0.968
RER	0.94	0.12	0.8–1.3	0.98	0.15	0.82–1.6	0.141

SD — standard deviation; HRpeak — peak HR during exercise test; %HRmax — peak heart rate as a percentage of maximum heart rate for age (220 – age); MET — metabolic equivalent; VO_2peak — peak oxygen consumption; RER — respiratory exchange ratio

Psychological intervention included teaching relaxation techniques by a psychologist and education regarding life philosophy, attitude to life, and lifestyle. During individual sessions with a psychologist, patients were offered support and help with solving their problems. Psychological intervention also included elements of emotional support, stimulation of self-confidence, and increasing self-esteem. Each patient underwent one-time psychological consultation to discuss psychological tests results and offer psychological support. In addition, all patients participated in one-time group education regarding coping with stress.

Patients participating in the CCR program learned ways to cope with stress and increased their knowledge regarding elimination of habits associated with cardiovascular risk (limiting activity, avoiding exercise).

Comprehensive education was undertaken by a cardiologist, psychologist, and dietician. Lecture topics included basic disease knowledge, benefits and aims of rehabilitation, and consequences of an adverse lifestyle. Patients were taught how to measure HR and blood pressure, and how to engage appropriately in exercise, including recreation and sport.

The study was approve by the bioethics committee at the Medical University of Gdansk (approval No. NKEBN/565/2006, dated Dec 27, 2006).

RESULTS

Mean body mass index (BMI) in the study group was 21.9 ± 2.9 kg/m², mean resting HR was 90 bpm, and mean patient age at the time of surgery was 5.18 ± 2.8 years. Mean age was 23 ± 3.4 years in the Reh group and 24.5 ± 4.8 years in the NReh group (p = 0.42). We found no significant differences between these two groups in body mass, BMI, resting HR, and blood pressure. General characteristics of the study group are shown in Table 1. Baseline CPET results in the Reh and NReh groups are shown in Table 2. We found no significant differences in physical capacity and exercise tolerance between these two groups.

Based on BDI results, the severity of depressive symptoms was higher in the NReh group compared to the Reh group, with mean values 3.9 (range 0–12; standard deviation [SD] = 3) and 1.97 (range 0–11; SD = 2.2), respectively (p = 0.004). Both objective and subjective quality of life measures, as evaluated using the Euro QoL 5D, did not differ significantly between the two groups (Table 3).

All patients completed the CCR program without complications. Exercise training was well tolerated. Moderate training intensity was used, rated 13 in the Borg scale. In all patients, CPET was performed twice, at baseline and after 30 days. During CPET, all patients reached peak exercise intensity at the

Table 3. Baseline psychologic tests in the rehabilitated (Reh) and non-rehabilitated (NReh) group

Variable	Reh (n = 31)			NReh (n = 26)			P
	Mean	SD	Range	Mean	SD	Range	
BDI	1.97	2.2	0–11	3.9	3	0–12	0.004
Objective QoL	84.9	7.9	66–100	86.2	7.3	73–100	0.608
Subjective QoL	79	7.6	60–90	76.9	10.4	50–98	0.434

SD — standard deviation; BDI — Beck Depression Inventory; QoL — quality of life

Table 4. Cardiopulmonary exercise testing results at 30 days in the rehabilitated (Reh) and non-rehabilitated (NReh) group

Variable	Reh (n = 31)			NReh (n = 19)			P
	Mean	SD	Range	Mean	SD	Range	
HRrest	74	8	60–88	81	14	47–98	0.01
HRpeak	163	13	152–182	152	23	100–195	0.052
%HRmax	83	6.9	62.5–92	77	11.5	52–98	0.036
Workload [W]	144	18.2	100–172	124	39.4	51–180	0.121
MET	7.8	1	5.7–9.4	6.6	1.7	25–91	0.003
VO_2peak	27.5	3.5	20–33	23	5.8	9–32	0.003
Duration of exercise [min]	14	1.9	10–18.4	11	4	4.1–20	0.001
SBP [mm Hg]	117	10	100–130	128	13	100–150	0.003
DBP [mm Hg]	74	6	60–80	81	7	70–100	0.005

SD — standard deviation; HRrest — resting heart rate; HRpeak — peak HR during exercise test; %HRmax — peak heart rate as a percentage of maximum heart rate for age (220 – age); MET — metabolic equivalent; VO_2peak — peak oxygen consumption; SBP — resting systolic blood pressure; DBP — resting diastolic blood pressure

level of 15–17 in the Borg scale without complications. Resting HR was lower in the Reh group (74 ± 8 bpm) compared to the NReh group (81 ± 14 bpm, p = 0.01). During CPET, patients in the Reh group reached significantly higher peak HR, higher per cent maximum HR, duration of exercise, peak VO_2, and workload (p = NS for the latter). Comparison of CPET results in the Reh and NReh groups at 30 days is shown in Table 4.

Patients in the NReh group showed non significantly higher severity of depressive symptoms compared to the Reh group, as evaluated using BDI at 30 days (mean score 4.8 vs. 2.2, respectively, p = 0.59). In contrast, subjectively and objectively rated quality of life was significantly higher in the Reh group compared to the NReh (score 89 vs. 74.4, p < 0.01; and 94 vs. 83, p < 0.01, respectively).

DISCUSSION

Development of modern cardiac surgical techniques resulted in an increasing number of beneficiaries of successful CHD correction. These patients are a growing group that desires and strives to live a complete life, with full accomplishment of aspirations and professional plans. Based on a history of correctly diagnosed and treated shunt CHD, this population should be completely healthy, the only difference being the presence of scars after a previous cardiac surgery in childhood [5]. Multiple evidence shows, however, that physical capacity of GUCH patients with a history of even simple CHD, such as VSD and ASD II, is reduced compared to healthy peers [5, 10]. However, only few studies were reported on physical capacity of GUCH patients. Our findings indicate that a CCR program improves quality of life, physical capacity, and exercise tolerance late after surgical CHD correction. These results are consistent with previously published national and international data.

Problems reported by growing GUCH patients, who mostly consider themselves disabled, were the basis for the analysis of their health status and an attempt to create a CCR program. An additional stimulus was the fact that in the 2010 European Society of Cardiology guidelines for the management of GUCH, patients after ASD II or VSD correction are considered candidates for unlimited exercise, if neither pulmonary hypertension nor arrhythmias are present [10]. Recommendation regarding exercise and participation in sports should be tailored to individual patient capacity, current haemodynamic status and the risk of sudden haemodynamic decompensation or development of arrhythmia. Clinicians are, however, overly conservative when giving advice regarding exercise. It is known that regular exercise has a beneficial, well-documented effect of physical capacity, mental status, and reduction of the risk of acquired cardiac disease. Dynamic exercise is superior to a static one. Sudden

cardiac death during exercise is rare in patients with known cardiac status [11]. The issue of reduced physical capacity of CHD patients compared to healthy peer has been discussed in the literature [12]. Reports also available regarding reasons for limited exercise capacity following correction of CHD, including chronic deconditioning or inability to participate in sport activities. Studies were also published on physical capacity in children following cardiac surgery [13] but it is difficult to find data regarding physical capacity of young adults late after CHD correction. Trojnarska et el. [14] evaluated physical capacity in a group of patients aged 30–63 years with patent ASD II. These authors showed that despite relatively good physical capacity as evaluated subjectively, it was significantly reduced in these patients when measured in an objective way. These patients were likely not subjected to controlled training within rehabilitation programs and avoided exercise during daily life activities, and rehabilitation was mostly limited to the in-hospital period [4]. The 2006–2008 POLKARD studies indicate that most paediatric cardiology patients undergoing transition to adult care are patients with simple CHD, including 26% of patients after surgical correction of an isolated intracardiac septal defect. No controlled training programs exist in Poland for patients with corrected CHD. Multiple reports indicate a need to improve care for CHD patients and create dedicated GUCH centres that would provide professional, multispecialty care [4, 15]. Few data are available about way to rehabilitate those patients to improve and/or maintain good physical capacity and quality of life. We lack ready-to-use solutions, i.e., rehabilitation programs that might be reproducibly used as a standard approach in this patient group. Rehabilitation programs for GUCH patients are based on general recommendation regarding cardiac rehabilitation [16].

In our study group, rehabilitation was planned in accordance with the American Heart Association recommendations on physical training [17] but also based on our several years' experience in training in cardiovascular disease patients. A non-randomised selection of the group that was not subjected to CCR was a limitation of our study but we believe that it would be unethical not to offer rehabilitation to these patients. The intensity of exercise was determined based on CPET results. For safety reasons, ECG was monitored in each patients during training on cycle ergometer, and the intensity of general fitness exercises and Nordic walking was monitored by measuring HR. These measures reduced patient anxiety associated with continuation of physical training in non-supervised home conditions.

In addition to individual endurance training and standard general fitness exercises, team game training was also reported in the literature [18]. This form of physical activity seems justified during a late stage of cardiac rehabilitation, more as an approach to maintain rather than improve fitness. As expected, cardiac rehabilitation in our study group significantly improves exercise tolerance and physical capacity as measured during CPET. In terms of physical capacity, findings in these young adults became more similar to those in a control group (young healthy students) that was also studied in our centre [5]. An increase in the respiratory exchange ratio from the mean of 0.94 to 1.3 following training indicates a better ability to perform maximum effort, as confirmed by subjective assessment of perceived exertion (score 15–17 in the Borg scale). Thus, it seems that the CCR program resulted in improved adaptation of the cardiovascular system to exercise.

Of note, some patients in our study group showed high physical capacity at baseline, with peak VO_2 values up to 31 mL/kg/min. No significant improvement in physical capacity was seen in these patients following the rehabilitation cycle. These patients considered themselves generally physically active, and they participated in physical education classes at school. It may be thus concluded that among patients with simple shunt CHD without limitations regarding everyday physical activity according to the 36th Bethesda Conference, some subjects show good physical capacity. However, even these patients should be aware of dangers during strenuous exercise, such as development of arrhythmia or excessive blood pressure rise. Some of our patients showed a very low exercise tolerance (in one female patient, peak VO_2 during baseline CPET was 17 mL/kg/min and increased to 24 mL/kg/min at 30 days). The lower was baseline physical capacity, the higher was its improvement following completion of the CCR program. This argues for introduction of controlled training in this patient group.

In addition to evaluation of objective cardiorespiratory fitness parameters, in our study we also evaluated the severity of depressive symptoms (using BDI [8]), and the need for non-medical support that is often expressed by patients [19–21]. Depressive symptoms reduced only in the rehabilitated group. We found that the higher was the severity of depressive symptoms in the studied patients, the less likely they were to participate in the rehabilitation program and the lower was their enthusiasm for training. Quality of life also improved with CCR. Following completion of the rehabilitation program, patients were less likely to indicate anxiety and lower well-being in psychological tests compared to the evaluation before rehabilitation.

In summary, we found that physical capacity in GUCH patients was reduced at baseline but improved in the rehabilitated group compared to the non-rehabilitated group, which indicates the need for referring and selecting these patents for comprehensive programs of late rehabilitation. Our findings indicate that by offering comprehensive support, we can safely improve physical capacity and exercise tolerance, increase physical activity, improve quality of life and reduce depressive symptoms in this patient group. Thus, it seems justified to introduce a CCR program in patients late after CHD correction as a routine measure supplementing their comprehensive care.

CONCLUSIONS

1. Implementation of a CCR program improves physical capacity and exercise tolerance late after surgical correction of CHD.
2. CCR improves quality of life and reduces depressive symptoms in this patient group.
3. Introduction of CCR program seems reasonable as a supplement to the holistic care for GUCH patients.

Conflict of interest: *none declared*

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Ocena wpływu kompleksowej rehabilitacji kardiologicznej na wydolność fizyczną i jakość życia pacjentów w odległym okresie po kardiochirurgicznej korekcji wrodzonych wad serca

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Streszczenie

Wstęp: Ważnym etapem leczenia dorosłych pacjentów z wrodzonymi wadami serca po operacjach kardiochirurgicznych jest kompleksowa rehabilitacja kardiologiczna (CCR), jednak dostęp do tej formy terapii jest wciąż ograniczony. Brakuje polskich wytycznych dotyczących prowadzenia CCR, w tym treningów kontrolowanych u ,,młodych dorosłych", kilkanaście lat po zabiegu korygującym wrodzoną wadę serca.

Cel: Celem pracy była ocena wpływu CCR na wydolność fizyczną, tolerancję wysiłku, jakość życia i nasilenie objawów depresyjnych pacjentów w odległym okresie po chirurgicznej korekcji wrodzonych wad serca.

Metody: Do badania włączono 57 pacjentów z wrodzonymi wadami serca (30 kobiet i 27 mężczyzn) w wieku 23 ± 3,4 roku, w okresie minimum 12 miesięcy po zabiegu zamknięcia ubytku w przegrodzie międzykomorowej (VSD) lub ubytku w przegrodzie międzyprzedsionkowej typu *ostium secundum* (ASD II). Wszystkim pacjentom zaproponowano udział w programie CCR: 31 pacjentów wzięło udział w programie (grupa Reh), natomiast 26 pacjentów odmówiło udziału w programie CCR (grupa NReh). U wszystkich pacjentów wykonano wstępny test wysiłkowy spiroergometryczny na cykloergometrze rowerowym, stosując protokół typu ramp o początkowym obciążeniu 20 W i przyroście obciążenia 10 W na minutę. Test był limitowany maksymalnym zmęczeniem i standardowymi wskazaniami do przerwania próby wysiłkowej. Do oceny psychologicznej wykorzystano kwestionariusz Becka i test służący do oceny jakości życia — Euro QoL 5D. Po 30 dniach od badania wstępnego ponownie oceniono pacjentów z obu grup, stosując takie same narzędzia badawcze jak we wstępnym badaniu.

Wyniki: Podczas prób wysiłkowych wszyscy pacjenci osiągnęli maksymalny poziom zmęczenia na poziomie 15–17 punktów w skali Borga, bez towarzyszących powikłań. Spoczynkowy rytm serca był niższy w grupie Reh (74 ± 8/min) niż w grupie NReh (81 ± 14/min). Pacjenci z grupy Reh osiągnęli istotnie wyższy maksymalny rytm serca w czasie próby wysiłkowej; również współczynnik tętna maksymalnego był wyższy u osób trenujących. Obciążenie wysiłkiem było nieistotnie większe, natomiast czas trwania wysiłku znamiennie dłuższy w grupie Reh niż w grupie NReh, odpowiednio 144 W *vs*. 124 W ($p = 0,121$) oraz 14 min *vs*. 11 min ($p = 0,001$). Wyższe szczytowe zużycie tlenu (VO_2peak) uzyskały osoby z grupy Reh w porównaniu z pacjentami z grupy NReh (27,5 ml/kg/min *vs*. 23 ml/kg/min; $p = 0,003$). Wyższe nasilenie objawów depresyjnych wg Becka po zakończeniu programu stwierdzono w grupie NReh niż w grupie Reh (średnio 4,8 *vs*. 2,2 pkt; $p = 0,59$). Natomiast subiektywna i obiektywna jakość życia była wyższa w grupie Reh niż w grupie NReh, odpowiednio 89 *vs*. 74,4 pkt ($p < 0,01$) oraz 94 *vs*. 83 pkt ($p < 0,01$).

Wnioski: Wdrożenie programu CCR poprawia wydolność fizyczną, tolerancję wysiłku fizycznego, jakość życia i zmniejsza objawy depresyjne pacjentów w późnym okresie po chirurgicznej korekcji wrodzonych wad serca. Wprowadzenie programu CCR wydaje się celowe jako uzupełnienie holistycznej opieki w tej grupie pacjentów.

słowa kluczowe: wrodzone wady serca po operacjach kardiochirurgicznych, dorastający pacjenci z wrodzonymi wadami serca, rehabilitacja kardiologiczna, wydolność fizyczna

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