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Factors affecting adherence to physical training in the outpatient phase of rehabilitation, in patients after coronary artery bypass grafting

Aim	To evaluate the outpatient physical exercise (PE) compliance and the affecting factors in patients after coronary bypass (CB).
Material and methods	The study included 67 men with ischemic heart disease younger than 75 years who had had CB. All patients were randomized to 2 groups: group 1 exercised on a bicycle ergometer at the rehabilitation center, under the monitoring of medical staff; patients of group 2 performed home-based exercise (HBE) by dosed walking. In the preoperative period, at one month after CB, and after 3 months of exercise, the following was evaluated: clinical condition of patients in different groups, plasma concentrations of lipids, body weight index, waist circumference, echocardiography and bicycle ergometry data, and questionnaire data (SF-36, Bek's Depression Inventory). At 3 months of follow-up, the outpatient exercise compliance and the affecting factors were also evaluated.
Results	The study demonstrated the effectiveness of the proposed alternative 3-month program of home-based PE. Both the patients exercising on a bicycle and those performing HBE had increased exercise tolerance (ET) and improved blood lipid concentrations. The number of obese patients decreased. Also, depression severity decreased, quality of life (physical and psychological components) improved, and compliance with drug therapy increased in both groups. Analysis of the training attendance in the recommended period showed that patients who had undergone CB were insufficiently adherent to physical rehabilitation programs, regardless of the program type (home-based or monitored). The highest PE adherence was observed in men with the following characteristics: married, working urban residents, with a previous history of cardiovascular diseases, who had regularly taken medications in the preoperative period, and who also had higher quality of life.
Conclusion	The proposed outpatient 3-month physical rehabilitation programs increase the effectiveness of CB, which is evident as improved adherence to modifying cardiovascular risk factors, increased ET, optimization of the psychological status and quality of life, and improved compliance with drug therapy. However, despite the proposed alternative, home-based 3-month physical rehabilitation programs aimed at increasing the treatment compliance, the level of ET remained low. This requires further improvement of methods for monitoring and motivation of patients to physical rehabilitation and psychological support that would start already at the preoperative stage.

Keywords	Cardiological rehabilitation; physical exercise; compliance
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Introduction

Cardiovascular diseases (CVDs) remain the major cause of mortality worldwide, including in Russia. Coronary artery disease (CAD) is the leading cause of disability and death in the population. It is important to note that the Russian Federation, unlike the European countries, continues to have higher rates of morbidity and mortality for CAD in the working population despite optimizing emergency care for patients with CAD, the advances in modern cardiology in both medical and surgical treatment of CAD [1, 2]. CVD prevention is thus becoming increasingly important. Cardiac rehabilitation is a key method of secondary prevention of CVDs. Its significance and efficacy are undeniable as evidenced by lower cardiovascular mortality, fewer repeated hospitalizations, and a larger percentage of return to normal labor activity [3]. The efficacy of rehabilitation programs was proven by the Russian and foreign long-term practice and scientific research [4]. Cardiovascular rehabilitation

is indicated for most post-CABG patients, according to the corresponding national clinical guidelines [2].

Training is a key component of cardiac rehabilitation programs because it improves prognosis, increases exercise tolerance, and improves quality of life (QoL) [5]. According to the literature, however, only slightly more than 30 % of patients are involved in the proposed physical rehabilitation programs [6]. Only 50% of patients who had acute coronary events received recommendations for additional rehabilitation in the European study EUROASPIRE IV, and only 17% of patients followed the recommendations. At the same time, only 26% of all subjects participated in rehabilitation and prevention programs [7]. The ESC-EORP EUROASPIRE V trial, in which Russia were among 27 European countries, showed that most patients with CAD led unhealthy lifestyles (they smoked, did not follow dietary recommendations, and were sedentary) [8].

According to the PROFILE register [9], only 33.9% of cardiovascular patients complied with the recommendations for lifestyle changes, including training. Similar results were obtained in the REKVAZA register [10].

This is mostly due to a shortage of skilled professionals, poor coverage of prevention and rehabilitation matters in routing clinical practice, limited financing, and a general decrease in the number of rehabilitation facilities. Patients also tend to not adhere to rehabilitation.

One of the ways to solve those issues is to look for approaches to enhance the availability of rehabilitation programs and, as a result, the number of patients who participate in rehabilitation programs, such as the inclusion of at-home training in outpatient rehabilitation programs with various methods of monitoring their implementation by specialists.

However, despite the active inclusion of at-home training in rehabilitation programs, the literature provides no unequivocal answer whether post-CAPG patients are more adherent to training performed at rehabilitation centers or at home, and what factors may affect this indicator.

Objective

Assess adherence to outpatient training and affecting factors in patients who have undergone CABG.

Material and Methods

Patients were enrolled in the prospective randomized clinical trial from 2016 to 2018.

The trial was conducted in the Research Institute for Complex Issues of Cardiovascular Diseases. The trial complies with the Declaration of Helsinki on Ethical Principles and has been approved by the local ethics committee (Minutes No. 102 dated 08/12/2014). All patients included in the study signed the informed consent.

The study included 67 male patients with stable CAD from 18 to 75 years old (mean age 58.1±5.9 years) hospitalized for elective coronary artery bypass grafting (CAPG) under cardiopulmonary bypass (CPB).

Inclusion criteria: isolated CABG for stable CAD, signed informed consent to participate in the study.

Exclusion criteria: age over 75 years and absolute/relative contraindications to stress test [2], refusal to participate in the study.

Thirteen patients did not initially agree to participate in outpatient rehabilitation programs. The reasons for refusal were unwillingness to engage in the program, confidence that household load would be sufficient in the postoperative period, family matters, difficulties to get to the rehabilitation facility. Those patients were not included in the analysis.

All patients underwent elective CABG under normothermic CPB. The mean number of grafts was 2.5±0.7, and the mean duration of CPB was 87.5 ± 26.7 minutes.

Subjects were examined 5–7 days before surgical treatment, 1 month after surgery (after completing the first and second early in-hospital stages of rehabilitation) and 4 months (after completing the supervised three month course of the physical rehabilitation program).

Clinical and anamnestic status was analyzed, low-density lipoprotein (LDL) cholesterol was determined using a Konelab Prime 30/30i analyzer, echocardiography was performed on a Hewlett Packard device, QoL was assessed using the SF-36 questionnaire [11], presence and severity of depression were evaluated using the Beck questionnaire [12], adherence to the recommended drug and non-drug therapy was assessed in all subjects at baseline. Physical examination was performed, lipid profile was analyzed, echocardiography was performed, treadmill test on a Schiller ergometer with the determination of exercise tolerance was carried out, QoL and the presence and severity of depression were assessed at each next stage of the study (in 1 and 4 months after CABG). The adherence to outpatient training and the affecting factors were analyzed after the completion of the three month course of training.

Subjects received standard drug therapy (angiotensin-converting enzyme (ACE) inhibitors/angiotensin II receptor blockers (ARBs), beta-blockers, statins, acetylsalicylic acid), performed exercises with elements of respiratory gymnastics, dosed walking, and cycling.

After the second inpatient stage of rehabilitation (1 month after CABG), all patients were randomized using a random number table according to inclusion and exclusion criteria into two groups: Group 1 trained on a bicycle ergometer in the rehabilitation facility under the supervision of medical professionals for 3 months and Group 2 trained at home in the form of dosed walking also for 3 months.

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Analysis of the main preoperative clinical and anamnestic characteristics did not reveal statistically significant differences between the two groups (Table 1).

In Group 1, patients underwent a course of aerobic training on a bicycle ergometer in the rehabilitation facility 1 month after CABG, under the supervision of medical professionals 3 times a week for 3 months. Each training session had three periods: warm-up for 5 minutes (preparation), the main period lasting 15 minutes, and a 5-minute final period. Subject to adequate exercise tolerance [2], the main training period was increased by 3–5 minutes after each training and gradually achieved 30 minutes. The training power of the main period was initially 50% of the threshold exercise tolerance as assessed during stress test, and the recommended training heart rate (HR) was 70% of the maximum HR during ergometry. During the preparatory and final periods, patients rotated the pedals of the ergometer without load.

When the body adapted to the proposed load (lack of proper HR increase during training, insufficient increase on the Borg scale), the training power of the main period was increased by 10 W but not more than the maximum tolerated load.

In Group 2, patients trained at home in the form of dosed walking also for 3 months. Based on the bicycle ergometry data, the walking rate was calculated using the formula [2]:

$$WP = 0.042M + 0.15HR + 65.5,$$

where WP (step/min) is the recommended walking pace, M is the maximum tolerated load as assessed by ergometry (kgxm/min), HR is the HR achieved at the maximum load during ergometry.

The recommended training HR was 70% of the maximum HR registered during ergometry. The recommended frequency of training was at least 3 times a week. Training also included a preparatory period (5 min), a main period (15 min) and a final period (5 min). In case of good exercise tolerance, it was recommended to increase the main period of training by 3–5 minutes after each training and gradually bring it to 30 minutes. Walking pace during the preparatory and final periods was 20 steps slower than during the main period.

All patients were advised to complete self-control diaries to record blood pressure (BP) and HR before and after training, well-being, number and duration of trainings, and digital expression of the perceived exertion level using the Borg scale [13].

The number of steps was recorded using pedometers handed out to patients. Physician made phone calls to patients 3 times a week to monitor exercise tolerance and asked the following questions: did your HR and BP increased higher than the recommended levels before and after walking; how do you assess your exercise tolerance using the Borg scale; did you have new symptoms during or after training since the previous phone call; did you miss dosed walking sessions? If yes, please, specify the reason; do you keep your self-control diary? If not, please, specify the reason; do you take the recommended drug every day? If not, please, specify the reason; do you have any questions about the training program?

Table 1. Baseline clinical and anamnestic characteristics of patients before CABG depending of the rehabilitation program

Parameter	Cycling group (n = 31)	At-home training group (n = 36)	p
Age, years (M ± SD)	56.8 ± 6.1	58.4 ± 5.7	≥ 0.48
AH, n (%)	30 (97)	35 (97)	≥ 0.57
Duration of AH, years (M ± SD)	9.3 ± 8.2	8.9 ± 5.9	≥ 0.72
Duration of CAD, years (M ± SD)	4.3 ± 5.1	5.0 ± 4.2	≥ 0.35
History of MI, n (%)	23 (74)	28 (78)	≥ 0.31
History of PCI, n (%)	28 (90)	32 (89)	≥ 0.79
DM, n (%)	6 (19)	10 (28)	≥ 0.64
CHF NYHA FC, mean (M ± SD)	2.0 ± 0.3	1.9 ± 0.6	≥ 0.86
Angina FC, mean (M ± SD)	2 ± 0.3	2 ± 0.2	≥ 0.95
Smoking, n (%)	16 (51.6)	18 (50)	≥ 0.63
LVEF, % (Me [Q1; Q3])	61 [52; 63]	60 [53; 63]	≥ 0.88
BMI >25 kg/m2, n (%)	24 (77)	28 (77)	≥ 0.37
WC > 94 cm, n (%)	19 (61)	25 (66)	≥ 0.46
LDL cholesterol, mmol/L (Me [Q1; Q3])	2.9 [2.5; 3.4]	2.8 [2.4; 3.9]	≥ 0.29
ACE inhibitors/ARBs, n (%)	19 (61)	25 (69)	≥ 0.67
Beta blockers, n (%)	12 (39)	15 (42)	≥ 0.51
Acetylsalicylic acid, n (%)	22 (71)	29 (80)	≥ 0.64
Statins, n (%)	10 (32)	9 (25)	≥ 0.86
3–4 component background regimen, n (%)	9 (29)	12 (33)	≥ 0.37

LVEF, left ventricular ejection fraction; BMI, body mass index; WC, waist circumference.

Statistical analysis was carried the using Statistica 8.0 and SPSS Statistics 20.0. The adequacy of the sample size was determined using the formula for calculating the necessary size of a nonrepeated sample with a predetermined confidence factor (reliability) of 0.95 and a margin of sampling error of 10%. The hypothesis of normal distribution was verified using the Shapiro-Wilk test. Qualitative indicators are presented as the absolute values and percentages, quantitative indicators are expressed as the medians and interquartile ranges or the means (M) and standard deviations (SD). The Mann-Whitney non-parametric test was used to assess the differences in quantitative parameters in the independent groups. The Pearson's chi squared test was used to assess differences in qualitative parameters (Yates test was used to compare rate in two independent small groups). The intragroup changes of the parameters were evaluated using the Wilcoxon test. Differences were statistically significant with p being equal to or less than 0.05.

Later, a two-level hierarchical model was constructed for the complex assessment of risk factors (RFs) of poor adherence to training during the outpatient rehabilitation stage. The integral indicator characterizing the complex assessment of RFs was presented as an additive weighted evaluation of three integral indicators consisting of social and clinical factors, and factors characterizing drug treatment adherence.

The integral index for Group 1 (R_{11}) was calculated using the formula:

$$R_{11} = \sqrt{\frac{1}{3}\sum_{i=1}^{3} p_y^2};$$

for Group 2 (R_{12}) using the formula:

$$R_{12} = \sqrt{\frac{1}{4}\sum_{i=1}^{4} p_y^2};$$

for Group 3 (R_{13}) using the formula:

$$R_{13} = \sqrt{\frac{1}{3}\sum_{i=1}^{3} p_y^2};$$

All calculations were made using the values of prognostic coefficients of RF levels.

The complex integral indicator of the assessment if RF of non-adherence was calculated using the following formula:

$$R = 0.71 \times R11 + 0.116 \times R12 + 0.174 \times R13,$$

in which integral indicators of adherence of three groups of RFs being analyzed and the corresponding weighting coefficients were used. The higher the R value, the higher the risk of quitting training.

The likelihood of patient's adherence to training was calculated using the formula:

$$P(Y=1/GH, Rp, Bp, R) = \frac{2}{1+e^{-(24{,}094+0{,}053\times GH+0{,}005\times Rp-0{,}38Bp-36{,}772R)}},$$

where P is the prediction coefficient, 24.094; 0.053; 0.038; 36.772 is the regression coefficient; R is the integral indicator of the risk of quitting training, GH is the general health status, RP is role physical functioning, BP is bodily pain, e is an exponent (Euler's number).

A binary logistic regression model was then constructed to estimate the likelihood that the patient will continue training at the outpatient stage. The values of the resulting attribute Y were: 0 – the patient refused to continue training at the outpatient stage of rehabilitation, 1 – the patient continued training. The method of step-by-step inclusion was used. A ROC analysis was performed, and the specificity and sensitivity of the model were assessed to determine a threshold that allowed improving the quality of prognosis.

Results

The analysis of changes in lipid profile in both the cycling and at-home training groups after the completion of the three-month training program compared to preoperative values showed that LDL cholesterol decreased from 2.9 [2.5; 3.4] mmol/L to 1.9 [1.7; 2] mmol/L; p = 0.001 and from 2.8 [2.4; 3.9] mmol/L to 1.9 [1.7; 2.1] mmol/L; p=0.001, respectively. The number of obese patients (body mass index > 30 kg/m^2) decreased compared to preoperative numbers in the cycling group (from 26 % to 14 %; p=0.01) and the at-home training group (from 23 % to 15 %; p=0.03). Moreover, exercise tolerance as assessed by bicycle ergometry increased statistically significantly after 3 months of follow-up compared to the postoperative data (1 month) in the cycling group (from 75 [50; 75] W to 100 [100; 125] W (p=0.02)) and the at-home training group (from 75 [75; 75] W to 100 [100; 100] W (p = 0.03)). The analysis of the psychological status showed a decrease in the level of depression in the cycling group (from 9 [5; 11] to 6 [2; 9]; p = 0.03) and the at-home training group (from 10 [7; 10] to 5 [3; 8]; p = 0.03) compared to the preoperative data. QoL also significantly improved in terms of physical and mental health components in the cycling group (from 46.5 ± 9.1 to 74.8 ± 12.0; p = 0.001 and from 51.5 ± 10.9 to 68.6 ± 11.1; p = 0.01, respectively) and the at-home training group (from 46.4 ± 9.5 to 76.7 ± 11.0; p = 0.001 and from 49.7 ± 12.4 to 67.9 ± 10.7; p = 0.02, respectively) compared to the preoperative values. The number of patients receiving 3–4 component background therapy increased from 29% to 84% (p = 0.01) in the cycling group and from 33% to 86% (p=0.01) in the at-home training group compared to preoperative numbers. For all indicators, there were no statistically significant differences between the groups.

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There were no cases of myocardial infarction, episodes of angina progression, repeated revascularization, or ischemic stroke during the three-month rehabilitation program.

There were no statistically significant differences in training attendance during the recommended period (3 months) between the groups. Only 8 (26 %) patients in the group training in the rehabilitation facility and 11 (30 %) patients in the group of patients who trained at home completed ⅔ or more of all the proposed sessions (24 or more sessions), 12 (39 %) patients in the cycling group and 15 (42%) patients in the at-home training group attended more than 12, but less than 24 sessions (⅓ of all sessions). Less than 12 sessions (less than ⅓ of sessions) were attended by 11 (35 %) patients in the cycling group and 10 (28 %) patients in the at-home training group.

Exercise tolerance was statistically significantly higher according to the Borg scale in patients training at the rehabilitation facility than those who trained at home (16 and 14, respectively; p = 0.04).

Patients were divided into two groups to assess the factors determining adherence to three month training program of the outpatient rehabilitation stage: Group 1 – 40 patients who completed ⅓ or more of all recommended sessions within 3 months (12 or more sessions), Group 2 – 27 patients who completed less than half of all recommended sessions (less than 12 sessions).

Given a small sample size, an integral indicator was calculated, which reflected the patient's adherence to training at the outpatient rehabilitation stage and allowed reducing dimensionality with minimal loss of information. All possible preoperative RFs of poor adherence were divided into three groups: social, clinical factors, and factors characterizing adherence to drug therapy.

Then, prognostic coefficients characterizing patient's adherence to training were calculated for each factor in all three groups (Table 2). Group 1 included such social factors as education, employment, place of residence. Group 2 included such clinical factors as the presence of angina, history of revascularization, diabetes mellitus (DM) type 2. Group 3 included such RFs as regular drug therapy (ACE inhibitors/ARBs, beta-blockers, acetylsalicylic acid).

Integral indicators were then calculated for each of the three RF groups of patient's non-adherence to training at the outpatient rehabilitation stage. Weights were calculated for each integral indicator (Table 3).

Subsequent regression analysis revealed the most significant factors determining adherence to training, particularly, complex integral indicator of risk R (p=0.01) and components of QoL: general health status (GH; p=0.05), role physical functioning (RP; p = 0.02), bodily pain (BP; p = 0.03).

The likelihood that the patient would continue outpatient training was then assessed based on the binary logistic regression model, which included such factors as QoL, depression, and state and trait anxiety, patient's age, and the complex integral indicator.

The likelihood of continuing outpatient training decreases when R and BP increase and the QoL scores (GH and RP) decrease.

The ROC analysis assessed the specificity and sensitivity of the proposed model. Specificity was 91.5% and sensitivity was 45% with the threshold of adherence to training 0.5 and area under the ROC-curve of 0.789.

Discussion

Our findings showed that at-home training in the form of dosed walking is a safe alternative to training at the rehabilitation facility under the supervision of a health professional. Exercise tolerance increased, lipid levels in plasma improved, and the number of obese patients decreased in the cycling and at-home training groups. Moreover, the severity of depression decreased, QoL (physical and psychological components) increased, and the number of patients receiving 3–4 component therapy increased in the cycling and at-home training groups. Our previous studies confirm the evidence presented [14, 15]. These results are consistent with findings by Bravo-Escobar et al. [16], M. G. Bubnova et al. [17], which demonstrated the efficacy and safety of at-home physical rehabilitation in patients with CAD.

The efficacy of the treatment and favorable prognosis depend largely on the patient's adherence to the physician's recommendations. The level of adherence to drug and non-drug therapy remains low despite regular programs aimed at increasing adherence and detecting factors influencing the adherence.

There were no statistically significant differences in training attendance during the recommended period (3 months) between the groups. However, the adherence to training was insufficient in both groups.

Only 26% of patients who trained at the rehabilitation facility and 30% who trained at home completed ⅔ or more of the proposed sessions (24 or more sessions). Most patients in the cycling and at-home training groups (39% and 42 %, respectively) attended more than 12 but less than 24 sessions, and 35% of patients in the cycling group and 28% in the at-home training group attended less ⅓ of all recommended sessions. However, exercise tolerance was statistically significantly higher according to the Borg scale in patients training at the rehabilitation facility than those who trained at home (p = 0.04).

Data obtained by foreign and Russian researchers on the patient's adherence to physical rehabilitation programs

Table 2. Prognostic coefficients of the risk factors

Parameter		Number of patients with this level (class)	Number of patients who refused to continue training at this level (class)	Risk of quitting training (Py)	Prognostic coefficient (P2y)
Social risk factors (R11)					
Education	secondary	53	39	0.735849	0.541474
	higher	14	8	0.571429	0.326531
Activity	not employed	37	29	0.783784	0.614317
	employed	30	88	0.610000	0.360000
Residence	rural area	16	12	0.750000	0.5625
	urban area	51	35	0.686275	0.470973
Clinical factors (R12)					
Angina FC	2	62	43	0.693548	0.640000
	3	5	4	0.820000	0.481009
History of PCI	No	7	3	0.428571	0.537778
	Yes	60	44	0.733333	0.183673
DM	No	51	35	0.686275	0.5625
	Yes	16	12	0.750000	0.470973
History of MI	No	16	13	0.8125	0.660156
	Yes	51	34	0.666667	0.444444
Adherence to drug therapy (R13)					
ACE inhibitors/ ARBs	does not administer	23	18	0.782609	0.612476
	administers	44	29	0.659091	0.434401
BBs	does not administer	40	30	0.750000	0.562500
	administers	27	17	0.62963	0.396433
ASA	does not administer	16	13	0.812500	0.660156
	administers	51	34	0.666667	0.444444

Table 3. Weights of integral indicators

Integral indicator	Significance of differences (p)	Weight
R11	0.014	0.71
R12	0.086	0.116
R13	0.047	0.174

vary significantly, which is explained by different designs of trials and rehabilitation programs and makes it very difficult to compare the findings. However, despite the discrepancies, the results of the assessment of patient's adherence to rehabilitation programs are underwhelming. According to several authors, less than 50% of patients continue training 6 months after the completion of an in-hospital cardiac rehabilitation program, fail to comply with the doctor's recommendations on drug and non-drug therapy [1, 18–20]. According to Beatty et al. [21], the attendance of rehabilitation programs was less than 20 % after the index event. According to Ali et al. [19], 41.1% of patients quitted training at home and 69 % did not take the recommended drugs once month after the discharge from hospital for CABG. Nair et al. [22] showed that only 11.6 % of patients were adherent to the physician's recommendations for healthy lifestyle, 35 % had uncontrolled arterial hypertension, and 48.4 % had hypercholesterolemia 6 months after myocardial revascularization. According to the literature, the age from 25 to 50 years (45.08 %; p=0.016), married status (40.08 %; p = 0.017), male sex (p=0.050), higher education (p=0.02) are the major factors that positively influence the adherence to rehabilitation programs. Non-adherence to the treatment is due to forgetfulness and poor understanding of the importance of drug therapy [23, 24].

The regression analysis allowed identifying the factors that influenced the adherence to training at the outpatient rehabilitation stage, such as higher education, place of work, residence in the urban area, married status, preoperative angina, revascularization procedures, DM, adherence to drug therapy (ACE inhibitors/ARBs, beta-blockers, acetylsalicylic acid), higher QoL. Thus, it was shown that the likelihood of continuing outpatient

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training decreases when the complex integral indicator and BP increase and the QoL scores (GH and RP) decrease.

The presented data reflect the need to prepare the patient for surgical intervention beginning from the preoperative stage, which consists in informing and educating the patient, motivating him/her to perform the necessary recommendations in the postoperative period, psychological support.

Conclusion

Thus, the proposed three- month outpatient physical rehabilitation programs increase the efficacy of coronary artery bypass grafting, which is manifested by better adherence to changing the risk factors for adverse cardiovascular events, increased exercise tolerance, better psychological status, higher quality of life and adherence to drug therapy. However, despite the proposed alternative three month at-home physical rehabilitation programs aimed at increasing treatment adherence, adherence to outpatient training remained insufficient, which requires additional efforts to improve the methods of monitoring and motivating patients for physical rehabilitation and psychological support of patients beginning as early as the preoperative stage.

Limitations

Small size of the patient sample, limited participation in the rehabilitation program due to places of residence, limited duration of controlled training of 3 months.

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