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Comprehensive assessment of physical cardiac rehabilitation in the early post-infarction period: results of a prospective study

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ABSTRACT

Myocardial infarction (MI) remains one of the main causes of premature mortality and disability in patients worldwide, despite the widespread implementation of modern reperfusion treatment methods, such as percutaneous coronary interventions (PCI). The most crucial component of comprehensive management for patients after MI is cardiac rehabilitation, which includes structured physical training aimed at restoring the body's functional capabilities, reducing the risk of recurrent cardiovascular complications, and improving patients' quality of life.

The purpose of this study was to analyze the effectiveness of physical cardiac rehabilitation in patients after MI and PCI based on the assessment of changes in functional, hemodynamic, metabolic, and psycho-emotional parameters.

Materials and methods. The study included 68 patients (41 men and 27 women) aged 40-75 years who were receiving standard pharmacological therapy and underwent a 4-week physical rehabilitation program. The protocol was based on moderate-intensity aerobic exercises (walking, stationary cycling), breathing exercises, and elements of therapeutic physical training. The effectiveness of the program was assessed using a 6-minute walk test, echocardiography, monitoring of heart rate and blood pressure, analysis of heart rate variability (SDNN), lipid profile indicators and the level of high-sensitivity C-reactive protein, as well as psycho-emotional status according to the HADS scale.

Results. Upon completion of the 4-week cardiac

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rehabilitation program, a significant improvement in all analyzed parameters was observed in most patients. The distance covered in the 6-minute walk test increased from 320 m to 420 m ($p < 0.001$), indicating an increase in physical endurance. Left ventricular ejection fraction improved from 49.5% to 53.1% ($p = 0.002$), with especially significant improvement in the group of patients with initial systolic dysfunction. Autonomic homeostasis improved, as evidenced by an increase in SDNN from 72 to 93 ms ($p < 0.001$). Positive changes in lipid metabolism were also recorded in response to physical training: LDL levels decreased by 0.8 mmol/L ($p < 0.01$), and the proportion of patients achieving target values (<1.8 mmol/L) doubled. The hs-CRP level decreased from 4.8 to 2.9 mg/L ($p = 0.001$), indicating a reduction in inflammation. Additionally, an improvement in psycho-emotional well-being was noted, reflected by a decrease in anxiety and depression scores on the HADS scale by 2.7-2.9 points ($p < 0.001$).

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Infarktdan keyingi erta davrda jismoniy yurak reabilitatsiyasini kompleks baholash: prospektiv tadqiqot natijalari

Kalit so‘zlar:
miokard infarkti,
teri orqali koronar intervensiya,
yurak reabilitatsiyasi,
jismoniy faollik,
SDNN,
ikkilamchi profilaktika,
HADS,
lipid profili.

ANNOTATSIYA

Zamonaviy reperfuzion davolash usullari, jumladan teri orqali koronar intervensiyalar (TKI) keng joriy etilishiga qaramay, miokard infarkti (MI) butun dunyo bo‘ylab bemorlarda muddatidan oldin o‘lim va nogironlikning asosiy sabablaridan biri bo‘lib qolmoqda. MIdan keyin bemorlarni kompleks davolashning eng muhim tarkibiy qismi yurak reabilitatsiyasi hisoblanadi. U organizmning funksional imkoniyatlarini tiklash, takroriy yurak-qon tomir asoratlari xavfini kamaytirish va bemorlarning hayot sifatini yaxshilashga qaratilgan tizimli jismoniy mashg‘ulotlarni o‘z ichiga oladi.

Ushbu tadqiqotning maqsadi funksional, gemodinamik, metabolik va psixoemotsional ko‘rsatkichlardagi o‘zgarishlarni baholash asosida MI va TKIdan keyingi bemorlarda jismoniy kardioreabilitatsiya samaradorligini tahlil qilishdan iborat.

Materiallar va usullar. Tadqiqotga standart farmakologik terapiya olgan va 4 haftalik jismoniy reabilitatsiya dasturidan o‘tgan 40-75 yoshdagi 68 nafar bemor (41 erkak va 27 ayol) kiritildi. Protokol o‘rtacha intensivlikdagi aerobik mashqlar (yurish, statsionar velosipedda harakatlanish), nafas olish mashqlari va davolovchi jismoniy tayyorgarlik elementlariga asoslangan edi. Dasturning samaradorligi 6 daqiqalik yurish testi, exokardiografiya, yurak urishi va qon bosimi monitoringi, yurak ritmi

o‘zgaruvchanligi (SDNN) tahlili, lipid profili ko‘rsatkichlari va yuqori sezgir C-reaktiv oqsil darajasi, shuningdek, HADS shkalasi bo‘yicha psixoemotsional holat yordamida baholandi.

Natijalar. 4 haftalik kardioreabilitatsiya dasturi tugagandan so‘ng, bemorlarning aksariyatida barcha tahlil qilingan parametrlarning sezilarli yaxshilanishi kuzatildi. 6 daqiqalik yurish testida bosib o‘tilgan masofa 320 m dan 420 m gacha (p<0,001) oshdi, bu jismoniy chidamlilikning oshganligini ko‘rsatadi. Chap qorincha qon otish fraksiyasi 49,5% dan 53,1% gacha yaxshilandi (p = 0,002), ayniqsa dastlabki sistolik disfunksiyasi bo‘lgan bemorlar guruhida sezilarli yaxshilanish kuzatildi. Vegetativ gomeostaz yaxshilandi, bu SDNN ning 72 dan 93 ms gacha oshishi bilan tasdiqlandi (p < 0,001). Jismoniy mashqlarga javoban lipid almashinuvida ham ijobiy o‘zgarishlar qayd etildi: PZLP darajasi 0,8 mmol/l ga kamaydi (p<0,01), maqsadli ko‘rsatkichlarga (<1,8 mmol/l) erishgan bemorlar ulushi ikki barobar oshdi. hs-CRP darajasi 4,8 dan 2,9 mg/l gacha (p = 0,001) kamaydi, bu yallig‘lanishning pasayganini ko‘rsatadi. Bundan tashqari, psixoemotsional holatning yaxshilanishi qayd etildi, bu HADS shkalasi bo‘yicha xavotir va depressiya ko‘rsatkichlarining 2,7-2,9 ballga (p<0,001) pasayishi bilan ifodalandi.

Комплексная оценка физической кардиореабилитации в раннем постинфарктном периоде: результаты проспективного исследования

Ключевые слова:
инфаркт миокарда,
чрескожное коронарное вмешательство,
кардиореабилитация,
физическая активность,
SDNN,
вторичная профилактика,
HADS,
липидный профиль

АННОТАЦИЯ

Инфаркт миокарда (ИМ) остается одной из основных причин преждевременной смертности и инвалидности у пациентов во всем мире, несмотря на широкое внедрение современных методов реперфузионного лечения, таких как чрескожные коронарные вмешательства (ЧКВ). Наиболее важным компонентом комплексного ведения пациентов после ИМ является кардиореабилитация, которая включает в себя структурированные физические тренировки, направленные на восстановление функциональных возможностей организма, снижение риска повторных сердечно-сосудистых осложнений и повышение качества жизни пациентов.

Целью данного исследования был анализ эффективности физической кардиореабилитации у пациентов после ИМ и ЧКВ на основе оценки изменений функциональных, гемодинамических, метаболических и психоэмоциональных параметров.

Материалы и методы. В исследование были включены 68 пациентов (41 мужчина и 27 женщин) в возрасте 40-75 лет, получавших стандартную фармакологическую терапию и проходивших 4-недельную программу

физической реабилитации. Протокол основывался на аэробных упражнениях умеренной интенсивности (ходьба, велотренажер), дыхательных упражнениях и элементах лечебной физкультуры. Эффективность программы оценивалась с помощью теста 6-минутной ходьбы, эхокардиографии, мониторинга ЧСС и АД, анализа вариабельности сердечного ритма (SDNN), показателей липидного профиля и уровня высокочувствительного С-реактивного белка, а также психоэмоционального статуса по шкале HADS.

Результаты. По завершении 4-недельной программы кардиореабилитации у большинства пациентов наблюдалось значительное улучшение всех анализируемых параметров. Расстояние, пройденное в тесте 6-минутной ходьбы, увеличилось с 320 м до 420 м ($p < 0,001$), что свидетельствует о повышении физической выносливости. Фракция выброса левого желудочка улучшилась с 49,5% до 53,1% ($p = 0,002$), особенно значительное улучшение наблюдалось в группе пациентов с исходной систолической дисфункцией. Улучшился вегетативный гомеостаз, о чем свидетельствует увеличение SDNN с 72 до 93 мс ($p < 0,001$). Положительные изменения в липидном обмене также были зарегистрированы в ответ на физические тренировки: уровень ЛПНП снизился на 0,8 ммоль/л ($p < 0,01$), а доля пациентов, достигших целевых значений (<1,8 ммоль/л), увеличилась вдвое. Уровень вч-СРБ снизился с 4,8 до 2,9 мг/л ($p = 0,001$), что свидетельствует об уменьшении воспаления. Кроме того, отмечалось улучшение психоэмоционального состояния, что отражалось в снижении показателей тревожности и депрессии по шкале HADS на 2,7-2,9 балла ($p < 0,001$).

RELEVANCE OF THE STUDY

Myocardial infarction (MI) remains one of the most significant medical and social problems in modern cardiology. According to the World Health Organization (WHO) data for 2023, cardiovascular diseases (CVDs) annually claim the lives of more than 17.9 million people, with up to 85% of such cases being related to myocardial infarction or stroke. Despite the introduction of high-tech treatment methods, including percutaneous coronary interventions (PCI), the risk of recurrent cardiovascular events, disability, and long-term mortality remains high.

In this context, secondary prevention is of particular importance, with cardiac rehabilitation being its key element. According to the recommendations of the European Society of Cardiology (ESC, 2021), participation in physical rehabilitation programs allows for a 20-30% reduction in overall mortality, a 26-27% reduction in the risk of reinfarction, and an 18-31% reduction in hospitalization rates. However, despite proven effectiveness, the coverage of patients with rehabilitation programs remains insufficient:

according to international registries, only 30-50% of patients after MI participate in rehabilitation activities, while in CIS countries, it is less than 20%.

The problem is exacerbated by the increasing prevalence of comorbid conditions such as type 2 diabetes mellitus, obesity, arterial hypertension, and physical inactivity, which aggravate the course of myocardial infarction (MI) and worsen the prognosis. In the Republic of Uzbekistan, according to the Ministry of Health (2023), the incidence of MI continues to rise, with cardiovascular diseases accounting for over 36% of overall mortality. Nevertheless, post-infarction rehabilitation systems remain insufficiently standardized: physical activities are often prescribed without considering the patient's clinical and functional status.

Under these circumstances, there is a need to conduct a clinical study aimed at objectively assessing the effectiveness of individualized physical cardiac rehabilitation in patients who have undergone MI and percutaneous coronary intervention (PCI). Particular attention should be paid to indicators such as exercise tolerance, echocardiography parameters, heart rate variability (SDNN), lipid profile, inflammation level (hs-CRP), and psycho-emotional status (according to the HADS scale).

The aim of the study is to assess the impact of a structured physical rehabilitation program on clinical, functional, hemodynamic, metabolic, and psycho-emotional indicators in patients with myocardial infarction after PCI.

Materials and methods

The study was conducted as a prospective single-center observational study at the Samarkand branch of the Republican Specialized Scientific and Practical Center of Cardiology in 2023-2024. The analysis included 68 patients of both sexes aged 40 to 75 with a confirmed diagnosis of acute myocardial infarction (with or without ST-segment elevation). All patients underwent primary PCI with blood flow restoration to TIMI 3 grade, and they were in a stable compensated state on days 7-10 after the intervention.

Exclusion criteria included severe heart failure NYHA class III-IV, uncontrolled arrhythmias, acute inflammatory or malignant diseases, as well as mental disorders that hindered adequate participation in rehabilitation. The study group comprised 68 people, of whom 60.3% were men. The mean age of the patients was 59.3 ± 7.6 years. The most common comorbidities were: arterial hypertension (81%), obesity (48%), and type 2 diabetes mellitus (36%).

Physical rehabilitation was conducted over 4 weeks and included aerobic training (walking, cycle ergometry), breathing exercises, and general strengthening exercises. Sessions were held 5 times a week for 30-45 minutes, with monitoring of heart rate, blood pressure, and blood oxygen saturation. The intensity of the exercises was 50-70% of the maximum heart rate (according to Karvonen), corresponding to 11-13 points on the Borg scale.

The effectiveness assessment included an analysis of functional capacity (6-minute walk test, MET), hemodynamics (HR, BP, echocardiography), heart rate variability (SDNN), lipid profile, hs-CRP, as well as psycho-emotional state (using the HADS scale). Data were processed using SPSS v25.0, employing Student's t-test and correlation analysis. Differences were considered statistically significant at $p < 0.05$.

RESEARCH RESULTS

The study demonstrated that a 4-week physical cardiac rehabilitation program following myocardial infarction in patients who underwent PCI has a pronounced

positive effect on functional, hemodynamic, neurovegetative, metabolic, and psycho-emotional parameters.

Table 1.

Dynamics of the 6-minute walk test results (n = 68)

Indicator	Before rehabilitation (m)	After rehabilitation (m)	p-value
Average distance	320 ± 54	420 ± 62	< 0.001

The average distance covered by patients in 6 minutes increased from 320 m to 420 m, corresponding to a 31% improvement. This change is both statistically significant ($p < 0.001$) and clinically significant, as it exceeds the minimal clinically important difference (MCID), defined as 25-30 m. An improvement of ≥100 m was achieved in 61.7% of patients, which is associated with increased aerobic endurance, improved circulatory reserve, and overall physical condition.

Table 2.

Left ventricular ejection fraction before and after rehabilitation

Indicator	Before rehabilitation (%)	After rehabilitation (%)	p-value
Left ventricular ejection fraction	49.5 ± 6.2	53.1 ± 5.9	0.002

LV ejection fraction improved from 49.5% to 53.1% ($p = 0.002$). The greatest improvement was observed in patients with initial LVEF ≤ 50%, where the average increase was +4.3%. Increased cardiac contractility indicates favorable myocardial remodeling and improved peripheral oxygen delivery as a result of regular physical exercise.

Table 3.

SDNN indicator (heart rate variability, n = 68)

Indicator	Before rehabilitation (ms)	After rehabilitation (ms)	p-value
SDNN	72 ± 13	93 ± 14	< 0.001

The average SDNN level increased by 21 ms ($p < 0.001$). Before rehabilitation, 38.2% of patients had reduced variability indicators (<70 ms), while after the rehabilitation course, only 7.3% maintained values below the threshold. This indicator demonstrates an improvement in the autonomic regulation of cardiac activity, a decrease in sympathetic hyperactivity, and a reduction in the risk of early arrhythmias.

Table 4.

Dynamics of heart rate and systolic BP

Parameter	Before rehabilitation	After rehabilitation	p-value
Heart rate (beats/min)	78 ± 11	71 ± 9	< 0.001
SBP (mm Hg)	138 ± 15	126 ± 13	< 0.001

A statistically significant decrease in heart rate and systolic blood pressure was recorded at rest. Heart rate above 80 bpm was observed in 45.5% of patients before rehabilitation, and only in 11.8% after. SBP ≥140 mm Hg decreased 3-fold. These effects indicate normalization of autonomic tone and improvement of vasoregulation.

Table 5.

Dynamics of lipid profile and inflammation indicators

Indicator	Before rehabilitation	After rehabilitation	p-value
Total cholesterol (mmol/L)	5.3 ± 1.1	4.4 ± 0.9	0.008
LDL (mmol/L)	3.2 ± 0.8	2.4 ± 0.7	0.005
Triglycerides (mmol/L)	1.9 ± 0.6	1.5 ± 0.5	0.04
HDL (mmol/L)	1.03 ± 0.18	1.14 ± 0.21	0.02
hs-CRP (mg/L)	4.8 ± 1.5	2.9 ± 1.2	0.001

Regular physical activity contributed to a decrease in total cholesterol and LDL, which, combined with an increase in HDL, improved the atherogenic profile. The level of inflammation (as measured by hs-CRP) decreased by 40%, reflecting the anti-inflammatory effect of aerobic exercise and the correction of metabolic disorders.

Table 6.

HADS score (n = 42)

Indicator	Before rehabilitation	After rehabilitation	p-value
Anxiety (points)	10.1 ± 2.4	7.4 ± 2.1	< 0.001
Depression (points)	9.2 ± 2.3	6.5 ± 1.8	< 0.001

Physical activity was accompanied by a significant decrease in anxiety and depression levels. The number of patients with clinically significant anxiety and depression decreased 3-4 fold, which confirms the important role of exercise therapy not only on the somatic but also on the psycho-emotional level.

The study results demonstrate a pronounced and multifaceted improvement in the condition of patients who have undergone MI with PCI after completing structured physical rehabilitation. Improvement in exercise tolerance, normalization of heart rate variability, stabilization of hemodynamics, metabolic processes, and psycho-emotional state confirm the necessity of mandatory integration of physical rehabilitation into the standard secondary prevention protocol.

CONCLUSIONS

The conducted study demonstrated that a 4-week physical cardiac rehabilitation program in patients who had undergone myocardial infarction with PCI had a pronounced positive effect on their condition. Patients experienced significant improvements in exercise tolerance (31% increase in distance during the 6-minute walk test), myocardial contractile function (3.6% increase in LV ejection fraction), and autonomic regulation (21 ms increase in SDNN).

Additionally, decreases in resting heart rate and blood pressure, improved lipid metabolism, and a reduction in inflammatory markers (40% decrease in hs-CRP) were

observed. The patients' psychological and emotional state markedly normalized, with anxiety and depression levels on the HADS scale decreasing by more than 30%.

Thus, physical rehabilitation has proven its effectiveness as a key component of secondary prevention in patients after myocardial infarction and should be incorporated into the standards of care for such patients.

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