



FACTOR STRUCTURE OF FUNCTIONAL PARAMETERS OF WOMEN WITH POSTMASTECTOMY SYNDROME WITH DIFFERENT LEVELS OF FUNCTIONAL STATE OF THE CARDIOVASCULAR SYSTEM

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Abstract

Modern approaches used in breast cancer treatment resulted in increasing survival rates. However, significant adverse events such as cardiotoxicity and cardiovascular complications remain high. A lot of women experienced fatigue, arrhythmias, heart failure, ischemic heart disease, and pulmonary side effects induced by breast cancer treatment.

The objective: to determine the features of the factor structure of functional parameters in women with postmastectomy syndrome with different levels of functional state of the cardiovascular system.

Methods: analysis of sources of literature and empirical data; rheography, spirometry, analysis of heart rate variability; anthropometry; mathematical statistics methods.

Results. a developed method for estimating the level of functional state of the cardiovascular system of women with postmastectomy syndrome based on age and objective indicators of central hemodynamics: heart rate, minute blood volume and left ventricular work, as well as their significant contribution to overall predicted level. Based on the values of the determined parameters and coefficients of multiple regression, criteria of levels of functional state of the cardiovascular system of patients with postmastectomy syndrome are determined. The proposed method allows to carry out rapid monitoring and with a high degree of probability to assess the functional state of the cardiovascular system of the patients with postmastectomy syndrome, as well as to determine the effectiveness of therapeutic, rehabilitation measures and make adjustments to the program of rehabilitation. Defined factors of the direction of the rehabilitation process with the integral account of the predicted level of the functional state of the cardiovascular system are in the manuscript. It has been identified that the hemodynamic factor has covered 22.37% of the dispersion in women with the low level of functional state, 21.24% – with the lower-than-average level, 22.06 – with the average level; expiratory – 17.15%, 16.74% and 17.48; vegetative – 11.21%, 13.29% and 12.97% at corresponding levels at outpatient rehabilitation stage.

Conclusions. obtained results are the basis for choosing priority means of physical rehabilitation during developing a program for the rehabilitation of women with postmastectomy syndrome with various levels of the functional state of the cardiovascular system.

Key words: functional state, cardiopulmonary system, women, postmastectomy syndrome.

Introduction

Lead sources of literature [5, 6] indicate that the breast cancer occupies a prominent position among the woman population. The most common consequence of the treatment of this disease is postmastectomy syndrome (PMS) that includes appearance of such symptoms as lymphostasis of an upper limb, cardiotoxicity, restriction of movement amplitude in the shoulder joint, disorders of

cardiovascular and respiratory systems, quality of life, negative psycho-emotional consequences, etc. [2, 4, 7, 11, 14, 15, 16].

Researches of the majority of scientists [1, 4, 8, 9, 10, 13] prove demonstratively that one hundred percent of the ill, which have already come through curative treatment of the breast cancer and have signs of postmastectomy syndrome, are in urgent need of both physical and psychological



rehabilitation, the adequate performance of which will favour a significant improvement in the somatic state of a patient. Estimation of level of the functional state of the cardiovascular system has a crucial role in defining abilities of a woman with the postmastectomy syndrome prior to performance of a load of various character, and may also serve as a criterion for the efficiency of a process of physical rehabilitation and a possibility of entering of adjustments in an exercise program [3, 13].

Despite a significant quantity of researches dedicated to the study of a physical state of people of various age groups, this issue among women with the postmastectomy syndrome is still scantily studied. Moreover, it is very important to take into consideration objective integral parameters of the cardiovascular system performance, which thoroughly characterize the level of the functional state and the definition of priority factors in choosing ways of physical rehabilitation of women in this nosological group.

Connection of the paper with scientific programs, plans, topics. The chosen direction of study corresponds to the topic of the scientific research work of Lviv State University of Physical Culture «The Basis of Physical Rehabilitation of Women with the Postmastectomy Syndrome» for 2016–2020 (state registration number 0115U007008).

The objective – definition of a factor structure of functional parameters of women with the postmastectomy syndrome with different levels of cardiovascular system functional state.

Methods

Methods: analysis of sources of literature and empirical data; rheography, spirometry, analysis of heart rate variability; anthropometry; mathematical statistics methods.

The research has been conducted on the basis of Zaporizhia Regional Oncology Dispensary and sport complex «Spartak» in Zaporizhia city. One hundred and fifteen women with the postmastectomy syndrome have taken part in the research, the average age of the women under study is $60,27 \pm 0,79$ years. According to the rate of dissemination of neoplastic process among women, the patients have been diagnosed with I, II-a and II-b stages of neoplastic process ($T_{1-2}N_{0-1}M_0$); all the ill have undergone a course of the adjuvant radiation therapy.

Functional state of the cardiovascular system has been studied with the help of chest rheography on the software and hardware system REOCOM (National Aerospace University «KhAI», Research and Development Center of Radio-electronic Medical Devices and Technologies «KHAI-MEDICA», Kharkiv).

Functional state of the respiratory system has been estimated with the help of a computer spirometry on a spirometer SMP–21/01–«R–D» of research, development and production company «Monitor».

The electrocardiographic complex CARDIOLAB with the function of analysis of heart rate variability (National Aerospace University «KhAI», Research and Development Center of Radio-electronic Medical Devices and Technologies «KHAI-MEDI-CA», Kharkiv, certificate of registration № 6037/2007) has been used for the evaluation of the functional state of the autonomic nervous system.

The technology of the analysis of heart rate variability has been based on the registration of short records (up to 5 minutes) of electrocardiographic signal of a patient, measurements of time intervals between R-waves of monitoring electrocardiogram (RR-intervals), composition of time series of RR-intervals (cardiointervalogramm or a rhythm strip) and the following analysis of the obtained rhythm strip by mathematical methods.

The methods of multiple regression analysis and factor analysis have been used. A calculation of a mathematical model of a predicted level of the physical state includes such characteristics: multiple correlation coefficient (R), determination coefficient (R^2), adjusted determination coefficient, calculation value of Fisher's ratio (F), standard error of equation, error and significance of indices of the regression equation. The factor analysis of parameters has been performed according to the method of a key component with varimax rotation of a factor matrix for simplifying the interpretation of obtaining the data. A decision on a quantity of the selected factors has been accepted on the basis of the sustainable use of Kaiser criterion, with the help of which irrelevant factors have been withdrawn and then the scree test of R. B. Cattell has been applied to the remain factors.

Results and discussion

Factors which have statistically relevant correlation coefficients have been attracted to the model of multiple regression for the estimation of the level of the functional state (LFS). In particular, the following results have been obtained from the calculation of parameters of the linear regression equation:

1. Multiple correlation coefficient (R) – 0,9705.
2. Determination coefficient (R²) – 0,9420.
3. Adjusted determination coefficient – 0,9406.

4. Calculation value of Fisher’s ratio test (F) – 650,34, p<0,001.
5. Standard error of equation – 0,03.
6. Intercept – 1,778981, p<0,001.
7. Indices of the regression equation and their level of significance: age – -0,006520, p<0,001; heart rate (HR) – -0,012944, p<0,001; minute blood volume (MBV) – 0,099369, p<0,001; left ventricular work (LVW) – -0,076928, p<0,001. Results of the calculation are given in Table 1.

Table 1

Results of the Multiple Regression Analysis of the Functional State Level of Women with the Postmastectomy Syndrome

Parameters	Results of a dependent variable regression: LFS, n=115 R= 0,9705; R ² =0,9420; Adjusted determination coefficient – 0,9406; F (4,160) = 650,34, p<0,001; Standard error: 0,03070					
	Beta	Std.Err.	B	Std.Err.	t	p-level
Absolute term			1,778981	0,034836	51,0680	0,001
Age, years	-0,283194	0,019123	-0,006520	0,000440	14,8088	0,001
HR, beats/min	-0,922899	0,019282	-0,012944	0,000270	-47,8627	0,001
MBV, l/min	0,503434	0,056771	0,099369	0,011206	8,8677	0,001
LVW, kgm	-0,483968	0,056967	-0,076928	0,009055	-8,4956	0,001

A normal allocation of remainders of the model according to visual and statistical analysis indicates an adequateness of the developed model of the level of the functional state prediction.

The received high determination index indicates that the variation of the level of the functional state of a person could be explained by variation of the factors added to the regression equation by 94,20 %, and only 5,80 % can be explained by the variation of the factors that are not considered in the regression equation. Apart from that, the great significance of the made regression equation is underlined by the Fisher’s ratio, the indices of which totals 650,34 (p<0,001). A standard error of estimation equals 0,03 and helps to define a confidence interval for the predicted level of the functional state with a probability of 97 %. In such a way it is possible to claim that the statistically significant regression equation has been obtained (the hypothesis concerning the fact that a quantitative estimate of the connection

between the dependent and the variable in the model, which they explain, is substantial).

Thus, the calculated model of estimation of the level of the functional state has the following form: LFS=1,778-0,006×(50+10×(A-58,97)/5,47))-0,012×(50+10×(HR-73,38)/8,98))+0,099×(50+10×(MBV-3,35)/0,63))-0,076×(50+10×(LVW-4,09)/0,79)),

in which LFS – the level of the functional state of the cardiovascular system;

A – age, years;

HR – heart rate, beats/min;

MBV – minute blood volume, l/min;

LVW – left ventricular work, kgm;

1,778 – absolute term of regression;

0,006; 0,012; 0,099; 0,076 – multiple regression coefficients;

58,97; 5,47; 73,38; 8,98; 3,35; 0,63; 4,09; 0,79 – constant coefficients.

The women who have been at the dispensary stage of rehabilitation have shown the following ratio of the functional state of the cardiovascular system (Fig. 1).

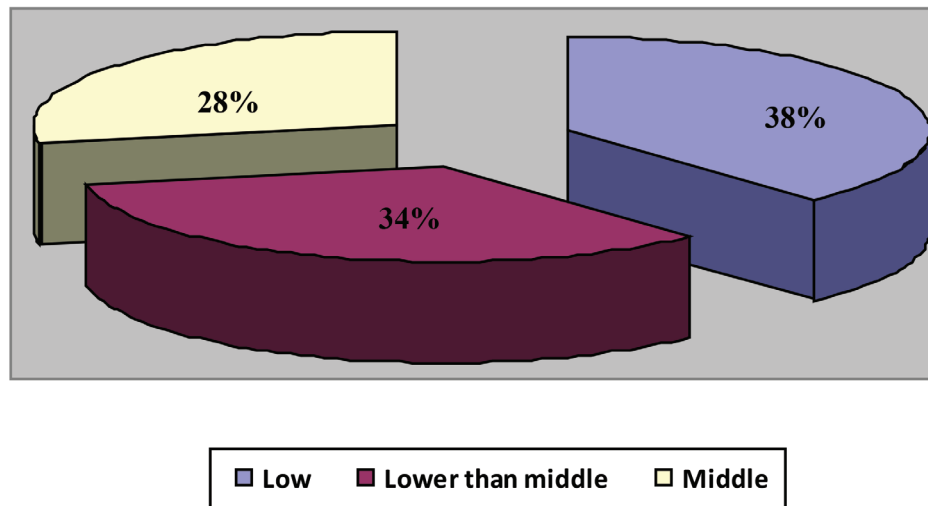


Figure. 1. Levels of the Functional State of the Cardiovascular System in Woman with the Postmastectomy Syndrome at the Dispensary Stage of Rehabilitation

According to the results presented in Figure 1 the majority of the women have had average 38 % (44 people) and lower-than-average – 34 % (39 people) levels of the functional state, the rest – 28 % (32 people) low level.

For generalization of certain correlation interconnections and grouping of measured functional parameters at every level of the functional state the factor analysis (53 parameters) of the cardiorespiratory and autonomic systems, as well as of the locomotor apparatus through the method of key components with varimax rotation of a factor matrix has been conducted. The quantity of separated factors has been approved on the basis of applying the scree test of R. B. Cattell.

The factor structure of functional sufficiency of patients with the postmastectomy syndrome with a

low level of the functional state at the dispensary stage of rehabilitation is demonstrated in Table 2.

The total percent of dispersion of all the factors of functional sufficiency of low level of the functional state of women after the radical mastectomy makes up 59,79 % and reflects a general factorization of an array of output parameters.

The most significant factor (haemo-dynamic, H) among the low level of the functional state of women explains 22,37 % of dispersion and consists of parameters of the central haemodynamics with the following factor loadings: stroke and minute blood volume ($r=0,90$), stroke index ($r=0,92$), cardiac index ($r=0,89$), left ventricular work ($r=0,75$); negative index of correlation has had a general peripheric resistance ($r=-0,88$), which immediately demonstrates the level of arterial blood pressure.

Table 2

Factor Structure of the Functional Sufficiency of Women with PMS with a Low Level of the Functional State at the Dispensary Stage of Rehabilitation

Factors		% of dispersion	The most significant parameters of a generalized factor	Factor loading
1	2	3	4	5
1	H	22,37	SBV	0,9017
			SI	0,9282
			MBV	0,9039
			CI	0,8983
			PVR	-0,8884
			CVW	0,5656
			LVW	0,7560
2	E	17,15	FEV ₁	0,8898
			PVV	0,9124
			MEF ₂₅	0,9593
			MEF ₅₀	0,8677

Table 2 continuation

1	2	3	4	5
3	V	11,21	SDNN	0,8522
			RMSSD	0,8857
			TP	0,8174
			HF	0,8568
4	VL	9,06	LF/HF	-0,7329
			Edema in a shoulder region	-0,7371
			Edema in a forearm region	-0,8104
			Edema in a hand region	-0,7887

To the second factor (expiratory, E), the percent of which from the general dispersion totals 17,15 % with high factor loadings, the following parameters have been included: forced expiratory volume in the first second (FEV₁, r=0,88), peak volume velocity (PVV, r=0,91), maximal expiratory flow at 25% of forced vital capacity of lungs (bronchi patency at the level of a large diameter, MEF₅, r=0,95), maximal expiratory flow at 50% of forced vital capacity of lungs (medium caliber, MEF₅₀, r=0,86).

To the third factor (vegetative, V), the percent of which from the general dispersion totals 11,21 %, the following parameters have been included: standard deviation of RR-intervals (SDNN), which characterizes a state of regulation mechanisms and points to the cooperative effect of the impact of sympathetic and parasympathetic segments of the autonomic nervous system on the sinus node (r=0,85), root mean square of the successive differences of RR-intervals (RMSSD), which is an indicator of activity of a parasympathetic part of the autonomic regulation (r=0,88), total power spectrum (TP, r=0,81), power in a range of high frequencies, which reflects the level of the respiratory arrhythmia and parasympathetic impacts on the heart rate (HF, r=0,85).

The fourth factor (vegetolympathic, VL), the percent of which from the general dispersion totals 9,06 %, has included parameters with a negative correlation sign sympathovagal index (LF/HF, r=-0,73), as well as the presence of an edema in a shoulder region (r=-0,73), in a forearm region (r=-0,81) and in an arm region (r=-0,78), in other words a decreased activity of a sympathetic segment is connected to the decline in lymphostasis.

The factor structure of the functional parameters of women with a lower-than-average level of the functional state is presented in Table 3. In a general structure of the functional sufficiency of these people it is possible to separate 4 factors, the general contribution of which to the dispersion totals 60,28 %. The first (haemodynamic, H, the percent from the general dispersion totals 21,24 %) and the second (expiratory, E, the percent from the general dispersion totals 16,74 %) encompass parameters of the cardiovascular and respiratory systems respectively similarly to the previous level.

That means that for the women with the low and lower-than-average levels of the functional state, the functional state of the cardiorespiratory system in particular assumes the paramount importance while creating a program of physical rehabilitation.

Table 3

Factor Structure of the Functional Sufficiency of Women with PMS with a Lower-than Average Level of the Functional State at the Dispensary Stage of Rehabilitation

Factors		% of dispersion	The most significant parameters of a generalized factor	Factor loading
1	2	3	4	5
1	H	21,24	SVB	0,9014
			SI	0,9264
			MBV	0,9393
			CI	0,9646
			PVR	-0,9183
			LVW	0,8627



Table 3 continuation

1	2	3	4	5
2	E	16,74	FEV ₁	0,8367
			PVV	0,8396
			MEF ₂₅	0,8603
			MEF ₅₀	0,8585
3	V	13,29	SDNN	0,8659
			RMSSD	0,8372
			TP	0,8471
			HF	0,8908
			Si	-0,8033
4	VL	9,01	VLF	-0,6112
			Edema in a shoulder region	-0,6213
			Edema in a forearm region	-0,5939
			Edema in a hand region	-0,5885

The third factor (vegetative, V, the percent from the general dispersion totals 13,29 %) has combined the parameters of autonomic regulation, which are indicative of the increase in total activity of the regulatory systems predominantly by means of parasympathetic impacts connected to the improvement of self-regulation processes, increase in the functional reserve of the organism and decrease in the strain of the regulatory systems.

A special attention should also be paid to the fourth factor (vegetolymphatic, VL), which includes

a very low-frequency spectrum element with a negative index of correlation (VLF, $r=-0,61$), that reflects a contribution of central ergotropic impacts, as well as parameters of an edema in shoulder, forearm and hand regions with corresponding factor loadings $r=-0,62$, $-0,59$ and $-0,58$.

Accumulative percentage of the dispersion of all the factors of functional sufficiency of the patients with the average level of the functional state (Table 4) totals 60,33 % and reflects the general factorization of an array of output parameters.

Table 4

Factor Structure of the Functional Sufficiency of Women with PMS with the Average Level of the Functional State at the Dispensary Stage of Rehabilitation

Factors		% of dispersion	The most significant parameters of a generalized factor	Factor loading
1	H	22,06	SBV	0,8865
			SI	0,8840
			MBV	0,9140
			CI	0,9014
			PVR	-0,8703
			LVW	0,8502
2	E	17,48	FEV ₁	0,8580
			PVV	0,9479
			MEF ₂₅	0,9444
			MEF ₅₀	0,9341
3	V	12,97	RMSSD	0,6226
			TP	0,9415
			LF	0,6386
			HF	0,7359
			Amo	-0,7185
			SI	-0,8033
4	VL	7,82	CVW	0,8455
			LF/HF	0,5661

In comparison with the previous level of the functional state the first factor (haemodynamic, H) has combined 22,06 % of the general dispersion, the second (expiratory, E) – 17,48 %, the third (vegetative, V) – 12,97 %, the fourth (vegetohaemodynamic, VH) – 7,82 %.

In the fourth factor of functional sufficiency of the women with the average level of the functional state, as opposed to the two previous levels, it is possible to trace the dependence of the haemodynamic index – left ventricular work (LVW, $r=0,84$) with increase in the level of sympathovagal index and with the shift of the adjustment to the sympathetic nervous system.

The results of our researches confirm the thought of researchers concerning the fact that after the given surgical treatment of the breast cancer and the adjuvant radiation therapy it is noted that the women have the malfunction of the cardiorespiratory system, which requires elaboration of special actions on their alleviation.

In such a way, the obtained results give us grounds for a choice of priority means of physical rehabilitation during developing the program of rehabilitation of women with the postmastectomy syndrome with different levels of the functional state of the cardiovascular system.

Conclusions

The developed means of determining the cardiovascular system functional state level of an organism of a woman with the postmastectomy syndrome includes determining age, heart rate, minute blood volume and left ventricular work on the basis of objectively specified characteristics of the central hemodynamics with consideration of their significant indices in the structure of the integrated parameter. In the factor structure of functional sufficiency of the patients at the dispensary stage the hemodynamic parameter has comprised 22,37 % of dispersion in the women with the low level of the functional state of the cardiovascular system, 21,24 % – with the lower-than-average one, 22,06 % – with the average one; expiratory – 17,15 %, 16,74 % and 17,48 %; vegetative – 11,21 %, 13,29 % and 12,97 % at the corresponding levels.

Directions for future research consider defining the specifics of the quality of life of women with the postmastectomy syndrome with different levels of the functional state of the cardiovascular system.

Conflict of interest

The author claims that there is no conflict of interest.

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