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The individualization of estimation of changes in the reaction of the cardiovascular system to the procedure of manual therapy of the thoracic spine in men with a vertebral thoracalgia in the sanatorium-resort treatment' course

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Abstract.

Purpose

The purpose of this study was to evaluate the reaction of the cardiovascular system of men with vertebral thoracalgia to manual therapy procedures on the chest during the course of sanatorium-resort treatment of spinal osteochondrosis.

Material and methods

Under supervision were 26 men aged 32.3 (27.9; 42.9) years who underwent a course of sanatorium-resort treatment for vertebral thoracalgia in the clinical sanatorium named after V.P. Chkalov (Odesa, Ukraine) in 2010-2011. The treatment complex included of 4 thoracic spine manual therapy (TSMT) procedures, which were performed every 5-7 days of sanatorium-resort treatment. The indicators of the cardiovascular system were recorded using the Omron M1 Classic device (Japan) in a supine position before and after every procedure TSMT.

Results

The results obtained in this study indicated sufficiently characteristic significant changes in heart rate (min^{-1}), which mainly decreases, DBP (mm Hg), which mainly increases, PBP (mm Hg), which mainly decreases in each of the procedures TSMT in men with vertebral thoracalgia.

Separately, according to the data of the rank evaluation of changes in indicators, the types of response of the contractile function of the heart (Δ Double product) and autonomic support of hemodynamics (Δ Index Kerdo) in men were characterized. They showed that there are individual differences in response to the TSMT procedure in the course of sanatorium-resort treatment.

Conclusion.
Determining the changes in ∆ Double product and ∆ Index Kerdo for the procedure of manual therapy of the thoracic spine made it possible to develop criteria for evaluating the types of response of the contractile function of the heart and autonomic support of hemodynamics. Their analysis in the course of sanatorium treatment of patients with thoracalgia showed that there are individual characteristics of reactions that should be taken into account in order to prevent the occurrence of negative effects of the TSMT procedure.

Keywords: thoracic spine manual therapy, thoracalgia, cardiovascular system, double product, kerdo index, types of reactions, individual estimation.

Introduction

Incorrect posture, changes in biomechanics of movements, hypodynamia are the causes of structural changes in the spine and pain (Briggs et al., 2009). The impact of physical and psychosocial factors at work and at home, emotional problems, uncomfortable working posture, use of smartphones, tablets and poor working conditions can be the causes of pain and incorrect position of the spine (Cagnie et al., 2007; Romanchuk & Ganitkevych, 2022). It can also lead to various dysfunctions in the musculoskeletal system, the activity of the cardiovascular and respiratory systems, which affect the functional state of the patient and his quality of life (Araujo et al., 2019; Romanchuk & Hanitkevych, 2022c). A significant number of publications have appeared that testify to the negative impact of spinal disorders on the human endocrine and immune system (Haas et al., 2024; Chow et al., 2021).

The largest number of scientific publications on the treatment and rehabilitation of spinal injuries is devoted to problems with the lumbar and cervical spine (Beyer et al., 2022; Núñez-Cortés et al., 2021), the lesions of which significantly limit people's work capacity, cause pain and limit mobility (Audette et al., 2010; Bialosky et al., 2009). This also applies to the provision of assistance in the form of various types of manual therapy, which is one of the main methods of treatment and rehabilitation of this category of patients (Locher et al., 2022; Heneghan & Rushton, 2016).

Thoracic pain is one of the indications for thoracic spine manual therapy (TSMT) (Koziolkin et al., 2019; Pecos-Martín et al., 2017; Briggs et al., 2009). However, it is also indicated for neck pain (Fernandez et al., 2020; Joshi et al., 2019; Kim et al., 2021; Cagnie et al., 2007; Cleland et al., 2007), shoulders (Walser et al., 2009; Muth et al., 2013; Casanova-Mendez et al., 2014), adhesive causulitis (Edmondston et al., 2012; Page et al., 2014) and persistent subclinical dysfunctions or chronic pain in other areas of the upper (Berglund et al., 2008; Walser et al., 2009; Funabashi et al., 2021) limbs. According to epidemiological studies, isolated thoracalgia occurs in 18.7% of men and 16% of women (Roquelaure et al., 2014). An analysis of the prevalence of thoracalgia in the Norwegian population (Leboeuf-Yde et al., 2009) is 13%, which is significantly lower than low back pain (43%) and neck pain (44%). A survey conducted by Briggs et al. (2009) made it possible to establish that the lifetime prevalence of thoracalgia ranges from 3.7% to 77% in different categories of the population.

The interest of clinicians in TSMT has grown significantly in recent years, especially with the emergence of evidence demonstrating significant effects on the function of the cardiovascular, respiratory, autonomic nervous, endocrine, and immune systems (Amatuzzi et al., 2021; Araujo et al., 2019; Gera et al., 2019, Hinkeldey et al., 2020; Haas et al., 2021; Chow et al., 2021; Kovanur Sampath et al., 2021; 2024a; 2024b; Stępnik et al., 2024). The results of the use of TSMT in diseases of the respiratory system

(Engel et al., 2013; Leonés-Macías et al., 2018; Simonelli et al., 2019), disorders of the functional state of the respiratory system (Fernández-López et al., 2021; Romanchuk & Hanitkevych, 2022c) are convincing. The results of a meta-analysis (Gera et al., 2020;) showed that mobilization and manipulation techniques significantly affect the cardiovascular system and reduce systolic and diastolic blood pressure, although the reduction in heart rate is not significant. These effects are not always unambiguous and depend on the place of application of techniques, their intensity and existing changes in the thoracic spine (Goertz et al., 2016; Sillevis et al., 2010). Thus, the results obtained during the study of practically healthy persons and persons with hypertension, which indicated significant differences in reactions to the manual therapy procedure, are noteworthy (Ward et al., 2013; 2015). The effects of TSMT on heart rate variability are ambiguous (Liem et al., 2024; Roura et al., 2021; Rechberger et al., 2019; Romanchuk, 2022a), although in most cases an increase in parasympathetic tone is noted. Such effects may be associated with not always clear localization of the influence aimed at a specific segment and individual features of the distribution of sympathetic fibers during the formation of the sympathetic trunk (Haas et al., 2024; Minarini et al., 2018; Henderson et al., 2010).

In general, the problem of assessing the impact of manual therapy of the thoracic spine on the functional state of the cardiovascular system is still insufficiently studied, which does not always allow to clearly characterize the effects of the impact in order to prevent negative consequences.

The purpose of this study was to evaluate the reaction of the cardiovascular system of men with vertebral thoracalgia to manual therapy procedures on the chest during the course of sanatorium-resort treatment of spinal osteochondrosis.

Research materials and methods.

Participants

Under supervision were 26 men aged 32.3 (27.9; 42.9) years who underwent a course of sanatorium-resort treatment for vertebral thoracalgia in the clinical sanatorium named after V.P. Chkalov (Odesa, Ukraine) in 2010-2011.

Methods the research was conducted in a manual therapy office of the clinical sanatorium named after V.P. Chkalov (Odesa, Ukraine). In the course of sanatorium-resort treatment, which lasted 21-24 days, treatment was carried out, which included the use of a number of physiotherapeutic and balneological procedures, as prescribed by a medical rehabilitation doctor on the basis of clinical history and examination. The treatment complex included 4 TSMT procedures, which were performed every 5-7 days of sanatorium-resort treatment.

Procedure:

The TSMT procedure included the following:

- mobilization of the thoracic spine
- manipulation techniques on the thoracic spine in the position of lying on the back and on the stomach (at the level of T_{1}-$_{6}$; T_{8}-$_{10}$)

  The duration of the procedure was 15-20 minutes

After the preliminary medical examination, the patients were in the supine position for at least 5 minutes. Then, in the supine position, the indicators of the cardiovascular system were recorded using the Omron M1 Classic device (Japan). The TSMT procedure was carried out, after which the patient was in a supine position for 5 minutes, at the end of which repeated registration of indicators of the cardiovascular system was carried out.

Inclusion/exclusion criteria

Inclusion criteria:

- ✓ frequent pain in the thoracic spine at rest or during movements;
- ✓ the presence of signs of osteochondrosis of the thoracic spine on radiographs;
- ✓ of subluxations on radiographs intervertebral joints in the thoracic spine;
- ✓ the presence of periodic disturbances of sensitivity in the upper limbs;
- ✓ absence of contraindications to TSMT (unstable fractures, severe osteoporosis, multiple

myeloma, osteomyelitis, ankylosing spondylitis in the inflammatory phase, spinal cord tumor, Paget's disease and similar conditions);
- ✓ availability of informed written consent.

Exclusion criteria:
- ✓ operations on the spine in the last year;
- ✓ fractures of the spine or ribs in the past year;
- ✓ rheumatoid arthritis;
- ✓ blood pressure is more than 140/90 mm Hg at the time of the start of the procedure;
- ✓ untreated hypertensive disease II degree;
- ✓ hypertensive disease of the III degree;
- ✓ angina pectoris II-IV FC;
- ✓ unstable angina pectoris;
- ✓ persistent heart rhythm disturbances.

This study was approved by the Ethics Committee of the Odesa National Medical University (No. 101-24). All patients were informed about the study and signed an informed consent form before the trial.

Statistical analysis. The processing of the received results was carried out with the help of STATISTICA program for Windows (version 10.0), Microsoft Excel 2012. The data obtained are presented as a median with 25-75% (Q_1; Q_3) percentiles. Differences between initial and subsequent measurements were taken via the Wilcoxon matched-pairs test. The percentile method was used to develop the assessment criteria, which allows characterizing individual changes in physiological parameters within the defined ranges of the percentile distribution.

Results.

In the table 1 presents the morphometric parameters of the studied group of men.

Table 1. Morphometric parameters of the studied group of men at the beginning of treatment

Parameters	Value
Body height, cm	183.0 (173.0; 186.0)
Body weight, kg	81.3 (65.6; 98.2)
BMI, kg×m $^{-2}$	24.6 (19.9; 28.2)
Body square, m ^{2}	1.97 (1.80; 2.13)

In the table 2 shows the average changes in the cardiovascular parameters of men before and after each of the four TSMT procedures. Changes in HR (min^{-1}), Double product (c.u.) and Index Kerdo (c.u.) were unidirectional and stable under the influence of all four TSMT procedures, which significantly decreased. Neither procedure produced significant changes in SBP (mmHg) in normotensive men. Starting from the second procedure, a significant increase in DBP (mmHg) was noted, which was accompanied by a significant decrease in PBP (mmHg). At the same time, a significant increase in MBP (mmHg) was noted only after the fourth procedure from 91.0 (86.7; 97.7) to 94.5 (90.3; 100.0), $p = 0.002$.

That is, performing TSMT in normotensive men has a significant effect primarily on HR (min^{-1}) and DBP (mmHg), the changes of which are reflected in derived indicators - Double product (cu) and Index Kerdo (cu).

Table 2. Changes in the indicators of the cardiovascular system`s performance of men with vertebral thoracalgia under the influence of manual therapy procedures in the course of sanatorium-resort treatment (n=26), (Q_1; Q_3)

Parameters	Before	After	Valid - N	T	Z	p-value
1 procedure						
SBP, mmHg	128.0 (115.0; 136.0)	128.5 (116.0; 137.0)	24	141.5	0.24	0.808
DBP, mmHg	78.0 (73.0; 86.0)	80.5 (74.0; 86.0)	25	101.0	1.65	0.098
PBP, mmHg	49.0 (42.0; 53.0)	47.5 (41.0; 54.0)	25	95.5	1.80	0.071
HR, min $^{-1}$	73.0 (67.0; 83.0)	68.5 (61.0; 73.0)	24	9.0	4.03	**0.000**
MBP, mmHg	94.0 (86.3; 101.7)	94.5 (88.7; 101.7)	26	126.0	1.26	0.209
Double product , cu .	91.0 (81.7; 108.7)	82.2 (73.8; 96.6)	26	43.0	3.37	**0.001**
Index Kerdo, cu .	-0.07 (-0.23; 0.07)	-0.17 (-0.40; -0.09)	25	12.0	4.05	**0.000**
2 procedure						
SBP, mmHg	127.0 (118.0; 135.0)	127.0 (116.0; 131.0)	20	84.5	0.77	0.444
DBP, mmHg	77.0 (73.0; 81.0)	81.5 (75.0; 85.0)	25	79.0	2.25	**0.025**
PBP, mmHg	50.0 (44.0; 56.0)	45.0 (40.0; 53.0)	25	66.0	2.60	**0.009**
HR, min $^{-1}$	70.0 (62.0; 80.0)	63.5 (59.0; 70.0)	25	17.0	3.91	**0.000**
MBP, mmHg	93.2 (88.7; 99.3)	95.8 (89.7; 100.0)	23	83.0	1.67	0.094
Double product , cu .	90.0 (78.4; 97.9)	81.8 (66.1; 87.0)	26	39.0	3.47	**0.001**
Index Kerdo , cu .	-0.09 (-0.19; 0.02)	-0.27 (-0.32; -0.14)	26	11.0	4.18	**0.000**
3 procedure						
SBP, mmHg	126.5 (119.0; 134.0)	123.5 (120.0; 128.0)	26	107.0000	1.74	0.082
DBP, mmHg	76.0 (70.0; 84.0)	80.5 (74.0; 84.0)	24	66.0000	2.40	**0.016**
PBP, mmHg	51.0 (43.0; 57.0)	44.0 (40.0; 48.0)	25	40.5000	3.28	**0.001**
HR, min $^{-1}$	67.0 (62.0; 79.0)	62.5 (58.0; 65.0)	26	33.5000	3.61	**0.000**
MBP, mmHg	92.7 (87.0; 98.3)	94.8 (89.0; 100.0)	26	161.0000	0.37	0.713
Double product , cu .	84.1 (77.5; 101.5)	74.9 (69.0; 80.0)	26	48.0000	3.24	**0.001**
Index Kerdo , cu .	-0.09 (-0.23; 0.01)	-0.28 (-0.37; -0.16)	26	12.0000	4.15	**0.000**
4 procedure						
SBP, mmHg	125.0 (117.0; 133.0)	124.0 (117.0; 132.0)	24	124.5000	0.73	0.466
DBP, mmHg	74.5 (68.0; 80.0)	80.0 (75.0; 86.0)	24	2.0000	4.23	**0.000**
PBP, mmHg	50.5 (44.0; 54.0)	45.0 (39.0; 49.0)	24	11.5000	3.96	**0.000**
HR, min $^{-1}$	66.5 (61.0; 73.0)	62.0 (57.0; 66.0)	24	17.0000	3.80	**0.000**
MBP, mmHg	91.0 (86.7; 97.7)	94.5 (90.3; 100.0)	26	54.0000	3.09	**0.002**
Double product , cu .	83.2 (76.5; 93.1)	78.7 (68.2; 84.5)	26	27.0000	3.77	**0.000**
Index Kerdo , cu .	-0.14 (-0.19; -0.06)	-0.26 (-0.41; -0.20)	26	1.0000	4.43	**0.000**

Note: Abbreviations: SBP – systolic blood pressure; DBP – diastolic blood pressure; PBP – pulse blood pressure; MBP – middle blood pressure; HR – heart rate.

Table 3 presents a comparative analysis of changes in cardiovascular system indicators from procedure to procedure - Δ SBP (mmHg), Δ DBP (mmHg), Δ PBP (mmHg), Δ HR (min^{-1}), Δ MBP (mmHg), Δ Index Kerdo (c.u.) and Δ Double product (c.u.). As a whole, they are of the same type in the group and do not differ significantly from procedure to procedure in the dynamics of rehabilitation treatment of vertebral thoracalgia. The only exception is ΔPBP (mmHg) after the third procedure, when it significantly decreases and even then only in comparison with the first procedure - 7.5 (-12.0; -1.0) versus -3.5 (-8.0; 2.0), p= 0.031.

Table 3. Comparative analysis of changes in indicators of the cardiovascular system from procedure to procedure in the course of sanatorium- resort treatment of patients with vertebral thoracalgia (n=26), (Q1; Q3)

	1 procedure	2 procedure	3 procedure	4 procedure	1-2	1-3	1-4	2-3	2-4	3-4
Δ SBP, mmHg	-1.0 (-5.0; 6.0)	0.0 (-6.0; 3.0)	-3.0 (-9.0; 4.0)	-0.5 (-6.0; 5.0)	0.893	0.146	0.770	0.166	0.882	0.166
Δ DBP, mmHg	2.5 (-3.0; 8.0)	3.5 (-3.0; 7.0)	2.5 (-1.0; 6.0)	4.0 (2.0; 7.0)	0.657	0.647	0.074	0.658	0.236	0.144
Δ PBP, mmHg	**-3.5 (-8.0; 2.0)**	-4.5 (-9.0; 2.0)	**-7.5 (-12.0; -1.0)**	-4.5 (-9.0; -2.0)	0.627	**0.031**	0.069	0.197	0.211	0.563
Δ HR, min^{-1}	-7.5 (-12.0; -2.0)	-5.5 (-13.0; -3.0)	-7.0 (-12.0; -1.0)	-3.5 (-7.0; -1.0)	0.886	0.533	0.288	0.829	0.280	0.149
Δ MBP, mmHg	2.2 (-2.3; 5.00)	0.2 (-3.7; 6.0)	0.2 (-2.7; 5.3)	3.2 (-1.0; 6.0)	0.869	0.684	0.368	0.361	0.402	0.082
Δ Double product , cu.	-10.1 (-16.6; -3.1)	-7.8 (-17.3; -1.2)	-7.7 (-19.5; -2.0)	-5.7 (-9.2; -2.0)	0.829	0.191	0.603	0.620	0.341	0.137
Δ Index Kerdo , cu.	-0.17 (-0.19; -0.08)	-0.17 (-0.23; 0.10)	-0.16 (-0.27; -0.04)	-0.15 (-0.24; -0.06)	0.328	0.454	0.258	0.790	0.970	0.929

Note: Abbreviations: SBP – systolic blood pressure; DBP – diastolic blood pressure; PBP – pulse blood pressure; MBP – middle blood pressure; HR – heart rate.

At the same time, the analysis of the individual dynamics of the indicators of the cardiovascular system showed that they have characteristic features in each of the patients, which may be due to the variability of structural and functional differences of this group of patients, as well as the characteristics of damage to segmental somatic and autonomic structures peripheral nervous system at the level of the thoracic spine.

In previous studies, the a priori ranges of statistically significant and expected changes in indicators of the cardiovascular system and hemodynamics were determined, which showed the most frequent (within the 25-75% percentile distribution), less expected (within the 5-25% and 75-95% percentile distribution) and rarely expected (within 0-5% and 95-100% percentile distribution) variants of changes (Romanchuk & Hanitkevych, 2022a; 2022b). From the standpoint of normality, they can be characterized as normal, moderately reduced and moderately increased, as well as markedly reduced and markedly increased (Panenko et al., 2004). Such a characterization of changes in the indicators of the cardiovascular system allows us to characterize them from the standpoint of the adequacy of the reaction to the TSMT procedure (Panenko & Romanchuk, 2006; Panenko & Romanchuk, 2024).

At the next stage of the study, in order to demonstrate the informativeness of this approach for assessing the individual impact of TSMT, changes in the integral indicators of the cardiovascular system of men with vertebral thoracalgia were analyzed, which reflect the degree of stress on the contractile function of the heart - the double product indicator, and autonomic support of hemodynamics - the Kerdo index. The ranked changes of these indicators in response to the TSMT procedure are presented in the table. 4. Given the range of ranks of the percentile distribution of these indicators, it is possible to characterize their type on the basis of physiological ideas about the processes that occur in the autonomic nervous system and the contractile function of the heart.

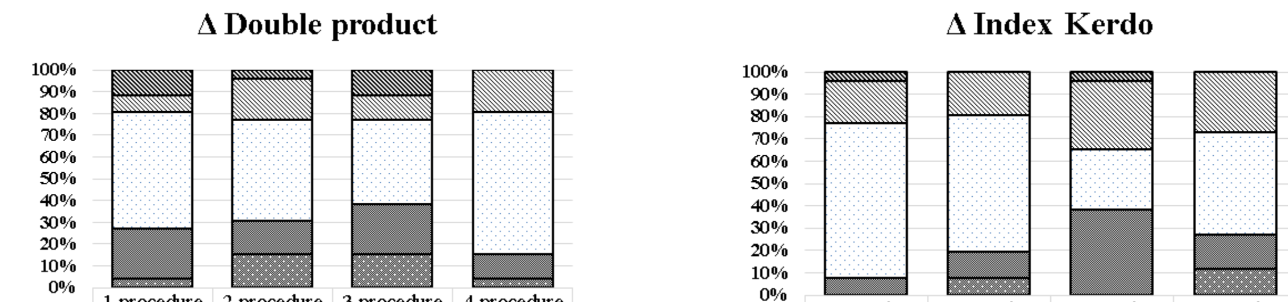
Table 4. A priori characteristics of reactions in the main indicators of cardiovascular activity in men under the influence of the manual therapy procedure

Parameter	Types of reactions				
	I type	II type	III type	IV type	V type
Δ Double product	<-34.8	-34.8 – -18.3	-18.2 – -3.1	-3.0 – 4.0	> 4.0
Δ Index Kerdo	<-0.45	-0.45 – -0.29	-0.28 – -0.12	-0.11 – 0.01	> 0.01

Taking into account the known approaches, the most optimal can be considered the values of changes that fall into the range of 25-75%. That is, this variant of the response of the autonomic nervous system (Δ Index Kerdo) and the contractile function of the heart (Δ Double product) can be characterized as the optimal type of reaction (Type III).

Previously, taking into account changes in these indicators, we proposed 5 types of response: Type I – excessively expressed; II type – pronounced; III type – optimal; IV type – acceptable; V type is inadequate (Panenko & Romanchuk, 2024). That is, this interpretation of changes in Δ Double product and Δ Index Kerdo allows to provide an individualized assessment of their reaction in response to the TSMT procedure. In turn, this may be the basis for warnings regarding possible inadequate reactions from the cardiovascular and autonomic nervous system in specific male patients with vertebral thoracalgia.

In fig. Figures 1a and 1b show the distribution of types of changes in the Δ Double product and Δ Index Kerdo indicators in men in the dynamics of the course of TSMT procedures. Considering their distribution, it can be stated that the individual reactions of the contractile function of the heart and the vegetative support of hemodynamics differ significantly from procedure to procedure. First of all, it is necessary to pay attention to a certain sequence of changes that relate to the increase in the economy of the contractile function of the heart (Δ Double product) from the first to the third procedure due to the increase of I and II types of reaction from 26.9% to 38.5%. At the same time, the number of optimal types (III type) decreases from 53.8% to 38.5%, and variants of inadequate reactions are at the initial level and occur in every 9 patient (11.5%). However, after the fourth procedure, the number of optimal types is 65.4%, and inadequate types are not registered at all. That is, it can be assumed that during the first three procedures, the most significant impact on the reconstruction of the hemodynamic support of the body occurs, which in the vast majority of men with vertebral thoracalgia is leveled off after the fourth procedure. After the first and second procedures, the changes in autonomic maintenance of hemodynamics were the most balanced in terms of a significant predominance of optimal reactions to the TSMT procedure - in 69.2% and 61.5% of cases. Similarly to the reduction of the contractile function of the heart, gradually from the first to the third procedure, the number of reactions that testify to the development of pronounced parasympathetic effects on hemodynamics increases from 7% to 38.5% of cases. At the same time, the number of optimal options for vegetative support of hemodynamics in the TSMT procedure is more than doubled from 69.2% to 26.9% of cases, which is accompanied by a significant increase in acceptable options from 19.2% to 30.8% of cases. At the same time, after the fourth procedure, a certain optimization of the autonomic reaction is noted, which nevertheless proves the presence of a certain imbalance with a tendency in 26.9% of patients to moderate sympathicotonia and in 26.9% to moderate and pronounced parasympatheticotonia.



	1 procedure	2 procedure	3 procedure	4 procedure
V type	11.5	3.8	11.5	0.0
IV type	7.7	19.2	11.5	19.2
III type	53.8	46.2	38.5	65.4
II type	23.1	15.4	23.1	11.5
I type	3.8	15.4	15.4	3.8

A

	1 procedure	2 procedure	3 procedure	4 procedure
V type	3.8	0.0	3.8	0.0
IV type	19.2	19.2	30.8	26.9
III type	69.2	61.5	26.9	46.2
II type	7.7	11.5	38.5	15.4
I type	0.0	7.7	0.0	11.5

B

Figure 1. Changes in the distribution of the response types of the contractile function of the heart (Δ Double product) and autonomic support of hemodynamics (Δ Index Kerdo) under the influence of the TSMT procedure in the dynamics of the course of sanatorium-resort treatment.

For example, we will give options for individual changes in the response types of the contractile function of the heart (Δ Double product) and autonomic support of hemodynamics (Δ Index Kerdo) in men with vertebral thoracalgia (Fig. 2) of different ages.

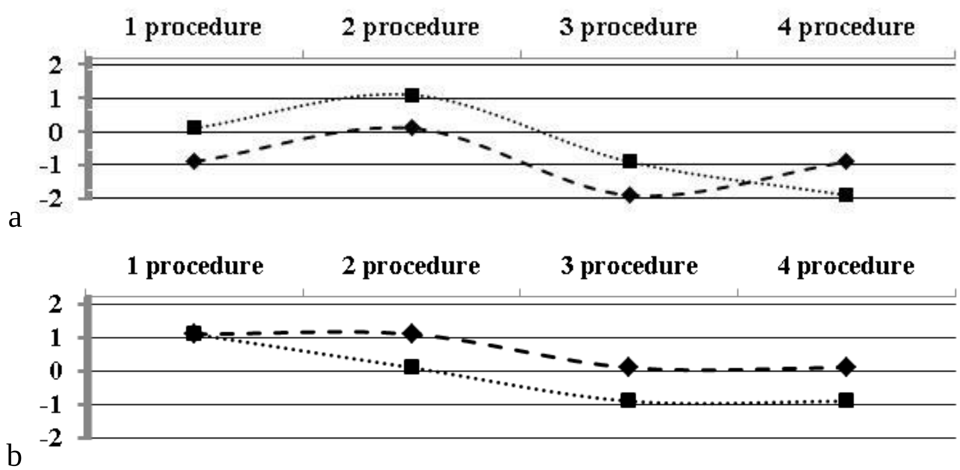


Figure 2. Individual changes in the response types of the contractile function of the heart and autonomic support of hemodynamics in men of various ages with vertebral thoracalgia in the TSMT procedure during the course of sanatorium-resort treatment.
a – patient K. 27 years old; b – patient N., 45 years old.

Discussion.

The problem of assessing changes in the activity of the cardiovascular system under the influence of TSMT mobilization and manipulation techniques lies in the plane of approaches to the registration of indicators, the position of the patient's body during registration, the duration of the manual therapy procedure, the time intervals between the application of the techniques and the beginning of the measurement, the stability of the changes, as well as the place the use of localized methods, which are often associated with certain manual therapy practices – classical practices, chiropractic, osteopathic, etc. (Mintken et al., 2008). Each of them has its own characteristics with the direction of techniques, body position, range of corrective influence (Guyatt et al., 2011). Therefore, even describing certain results often indicates a certain range of application of manual therapy. Only a small number of works emphasize a clear influence on one or another vertebral-motor segment of the thoracic spine. This is reflected in the research results, which in many cases makes their comparison impossible. First of all, noteworthy studies conducted by Ward et al. (2013; 2015) in which supine varied anterior chest manipulation was shown to have minimal effect on any of the cardiovascular physiological variables tested, although statistically significant changes in PQ interval and QRS duration were noted. Based on these results, the author concludes about the safety of manipulations on the upper thoracic spine in people with normal or elevated blood pressure. In previous studies, we have shown a significant effect on the duration of electrical systole (QTs) in men in contrast to women (Romanchuk, 2022b). With directed manipulations at the T_2 level; T_5; T_{11} vertebrae, the authors (Minarini et al., 2018) showed a significant increase in the activity of parasympathetic activity according to the RMSSD indicator. Other authors noted an ambiguous effect on HRV indicators, which testify to the activity of the central nervous system (Araujo et al., 2019; Amatuzzi et al., 2021; Gera et al., 2019; Romanchuk, 2022a).

The results obtained in this study indicated sufficiently characteristic significant changes in heart rate (min^{-1}), which mainly decreases, DBP (mm Hg), which mainly increases, PBP (mm Hg), which mainly decreases in each of the procedures

TSMT in men with thoracalgia. The absence of patients with high blood pressure allowed us to compare the obtained results of observations with normotensive patients examined earlier. This made it possible to conduct a ranking assessment of changes in indicators of the cardiovascular and autonomic nervous systems, as well as to evaluate the ranking dynamics of these indicators in the course of sanatorium-resort treatment of spinal osteochondrosis.

Separately, according to the data of the rank evaluation of changes in indicators, the types of response of the contractile function of the heart (Δ Double product) and autonomic support of hemodynamics (Δ Index Kerdo) in men of various ages with thoracalgia were characterized. They showed that there are individual differences in response to the TSMT procedure in the course of sanatorium-resort treatment.

The latter, in our opinion, is important for the individual assessment of the reactivity of the cardiovascular and autonomic nervous systems from the standpoint of predicting the development of possible complications of the TSMT procedure.

Conclusion.

Determining the changes in Δ Double product and Δ Index Kerdo for the procedure of manual therapy of the thoracic spine made it possible to develop criteria for evaluating the types of response of the contractile function of the heart and vegetative support of hemodynamics. Their analysis in the course of sanatorium treatment of patients with thoracalgia showed that there are individual characteristics of reactions that should be taken into account in order to prevent the occurrence of negative effects of the TSMT procedure.

Author's contribution

Conceptualization, AP and OR; methodology, OR; software, OR; check, AP, OR; formal analysis, AP; investigation, OR; resources, AP; data curation, OR; writing -rough preparation, AP and OR; writing -review andediting, AP; visualization, OR; supervision, AP; project administration, AP; receiving funding, AP. All authors have read and agreed with the published version of the manuscript.

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No

Conflict of Interest

The authors declare that it has nocompeting interests.

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