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ORIGINAL ARTICLE

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EFFICIENCY OF HIGH-INTENSITY GAIT TRAINING IN THE REHABILITATION OF POST-STROKE PATIENTS

Igor V. Kireyev[1], Natalia V. Zhabotynska[1], Dmytro A. Andriukhin[2], Mykhailo Yu. Sydorchuk[2], Karyna V. Tsemenko[1], Andrey L. Liashok[3]

[1]NATIONAL UNIVERSITY OF PHARMACY, KHARKIV, UKRAINE
[2]ALEF CLINIC, KHARKIV, UKRAINE
[3]V. N. KARAZIN KHARKIV NATIONAL UNIVERSITY, KHARKIV, UKRAINE

ABSTRACT

Aim: Research of the effectiveness of high-intensity gait training in the rehabilitation of middle-aged patients in different periods after a stroke.

Materials and Methods: Middle-aged post-stroke patients took part in the research. They performed either a comprehensive rehabilitation program with the addition of high-intensity gait training or only high-intensity gait training. All patients underwent an assessment of their functioning before and after rehabilitation programs. The following tests were used for assessment: the Berg Balance Scale, the Modified Rivermead Mobility Index, the Functional Ambulation Classification, the 10-meter walk test, and "Get Up and Go" test. The results were processed using statistical methods.

Results: The application of high-intensity gait training has demonstrated high efficiency in middle-aged post-stroke patients. Adding the method of high-intensity gait training to comprehensive rehabilitation programs demonstrated significantly higher efficiency than the use of only high-intensity gait training. At the same time, in post-stroke patients, in the early recovery period, the improvement in functioning was better than in the late recovery period.

Conclusions: Adding the method HIGT to the comprehensive rehabilitation of middle-age post-stroke patients leads to a significant improvement in their functioning, especially in the early recovery period.

KEY WORDS: high-intensity gait training (HIGT), middle-age post-stroke patients, early and late period after the stroke

INTRODUCTION

Stroke has already reached epidemic proportions. Over 110 million people in the world have experienced stroke [1]. According to official statistics, cerebrovascular diseases are the second leading cause of death among the population in Ukraine. In general, mortality from strokes in Ukraine is 13-14%. One year after a stroke, patients' disability ranges from 76 to 85%. After a stroke, no more than 10-12% of patients return to work, and 25-30% of patients remain with the disability of the first group for the rest of their lives [2]. The problems of rehabilitation of post-stroke patients are even more relevant due to the increase in the number of strokes in young and middle-aged people: "Stroke is no longer a disease of the elderly". Now, about 47,000 people of working age are affected annually [3]. Due to physical therapy, a post-stroke person can regain their ability to function: improve limb function, learn movement skills, positioning, self-care, and improve postural control. Also, the quality of life of stroke survivors increases after physiotherapy courses [4].

Unfortunately, in stroke rehabilitation, research continues to identify gaps between evidence and clinical practice. Because gait is so important for restoring function and improving patients' quality of life, physical therapists must use evidence-based interventions to achieve improved gait. One such method is high-intensity gait training (HIGT), which is a walking exercise performed with high repetitions that are intense enough to keep your heart rate above your target level. There is evidence that HIGT improves gait speed, distance, quality and symmetry [5]. A clinical practice guideline on locomotor strategies recommends the use of moderate- and high-intensity gait training for patients with diagnoses affecting the central nervous system [6]. A study by George T. Hornby with co-authors showed what exactly high-intensity stepping training resulted in greater improvements in walking ability and gait symmetry than low-intensity training in individuals with chronic stroke, with potential greater improvements in balance confidence [7].

AIM

The aim was to research effectiveness of HIGT in the rehabilitation of middle-aged patients in different periods after a stroke. It can be assumed that the use of HIGT will reduce recovery times, increase the quality and efficiency of the recovery process, and improve the patient's physical and psycho-emotional condition and quality of life. To realize

this purposes, the following tasks were set: to compare the effectiveness of high-intensity methods of physical therapy for post-stroke people according to the literature; perform functional diagnostics and assess the quality of life of post-stroke patients in different periods of recovery; to develop an algorithm for the use of HIGT as a method of physical therapy for middle-aged post-stroke people; to study the effectiveness of HIGT in middle-aged people in different periods after an ischemic stroke.

MATERIALS AND METHODS

40 post-ischemic stroke patients who suffered an took part in the study: 23 male (57,5%) and 17 female (42,5%). All patients belonged to the category of middle-aged persons according to the WHO classification [8]: the average age was 47,33 ± 3,28 years. Patients were in both the acute (7-28 days) and late (after 6 months) periods after ischemic stroke. Participants of research were required to walk 10 m without physical assistance but at self-selected speeds <1.0 m/sec, with their customary assistive devices. Exclusion criteria from the research: presence of additional damage to the central or peripheral nervous system, orthopaedic injuries that limit independent movement, signs of cerebellar ataxia, objective signs at rest: blood pressure (BP) above 180/110 mm Hg; heart rate (HR) 120 beats per minute, saturation below 92%, inability to follow commands.

All patients were divided into two groups. Group 1 consisted of 22 patients, 11 male and 9 female of middle age (47,4 ± 3,0 years), who received a complex rehabilitation program with the addition of the HIGT method. Group 2 included 18 patients, 12 male and 8 female of middle age (47,2 ± 2,96 years), who underwent rehabilitation using HIGT only. In order to evaluate the effectiveness of the applied methods depending on the period after the stroke, the patients were divided into two other groups: E Group – patients in the early period after the stroke and L Group – patients in the late period after the stroke. For a more detailed analysis, Group 1 and Group 2 were divided into two subgroups, depending on the period after stroke the patients were in. Groups of patients in the early and late period who received a complex rehabilitation program with the addition of the HIGT method are 1E Group and 1L Group, respectively. 2E Group and 2L Group groups of patients in the early and late period, which were used exclusively by HIGT.

HIGT was conducted 4 times a week, the 5th was the testing day, high intensity (heart rate was kept at 70-85% of the maximum permissible), lasting 45-60 minutes per day. The duration of the course is 3 weeks. The intervention started 6-7 days (E Group) and 6-7 months after the ischemic stroke (L Group). Training included high-intensity stepping training forward on a treadmill and over ground with minimal variability. All participants wore accelerometers on their paretic limb to estimate stepping amount and rate per session. Heart rates and saturation were monitored using pulse-oximeters, blood pressures were monitored and was measured by a physical therapist and documented every 3 to 5 minutes as possible. Training was stopped if the HR reached more than 85% of the maximum, and when taking beta blockers – more than 80%; BP above 210 by 110; saturation below 92%. The maximum HR was calculated according to the formula: 211–(0,64×age). If necessary, BP was corrected with beta-blockers within 15 mm Hg.

The Berg Balance Scale (BBS), Modified Rivermead Mobility Index (MRMI), Functional Ambulation Classification (FAC), 10-meter walk test, and "Get Up and Go" test were used to evaluate the effectiveness of rehabilitation programs.

The BBS was created to investigate the patient's functional capabilities, particularly balance and mobility, and risk of falling. The scale has 14 tasks, each of which is rated from 1 to 4 points. The maximum score that the patient can score is 56. Score 0-20 points – moving only on a wheelchair; 21-40 points – walking with help; 41-56 points – does not need assistance when walking. A score below 45 points indicates an increased risk of falls [9].

The RMI is a standardized assessment of mobility originally designed for persons with either head injury or stroke but has subsequently been validated in other populations as well. The RMI consists of 15 items (14 self reported items and 1 direct observation) [10]. The items are scored 0 if the patient is not able to complete the task or 1 if they are able to complete it. The points are then added together, to score a maximum of 15, with higher scores stipulating better functional mobility [11].

The FAC test was developed to determine walking independence. To conduct the test, you need 15-20 meters of flat surface and stairs. A score of 0 indicates that the patient is a non-functional ambulatory (can't walk). A score of 1, 2 or 3 denotes a dependent ambulatory who requires assistance from another person in the form of continuous manual contact (1), continuous or intermittent manual contact (2), or verbal supervision/guarding (3). A score of 4 or 5 describes an independent ambulatory that can walk freely on: level surfaces only (4) or any surface (5 maximum score) [12].

The 10-meter walk test was designed to determine the speed of walking a distance of 10 meters. For testing, it is necessary to measure at least 12 meters, mark the start and finish. The patient should stand 2 meters before the start, the use of aids is allowed. On command, the patient starts to walk, the timer starts when the patient crosses the starting line. Testing ends as soon as the patient crosses the finish line. In total, the patient has 3 attempts, the best result is recorded. To determine the speed, it is necessary to divide the distance by the time in seconds [13].

The "Get Up and Go" Test was developed to determine a patient's functional capacity and risk of falling. The test is evaluated by the amount of time required to complete the task. The patient sits on a chair, on command, he must stand up, walk 3 meters, walk around the marker, turn around and sit down, and the use of walking aids is allowed. The patient is given 2 attempts, the result of only the second is taken into account. A result longer than 20 seconds is considered unsatisfactory [14].

Statistical characteristics of the variables were presented using percentages, mean (M) ± standard deviations (SD). The

significance level was set at ($p \leq 0.05$) for all statistical procedures. The Bioethics Commission recognized the research materials as meeting scientific standards and ethical principles. All methods applied during the study complied with requirements of the Helsinki Declaration of the World Medical Association.

RESULTS

The studied groups were comparable in age; all patients belonged to the middle-aged category. In both groups, a significant ($p<0.05$) improvement in functioning was observed after receiving the rehabilitation programs according to the tests RMI, BBS, FAC, 10-meter walk test, and "Get Up and Go" test. The obtained results showed that in the group of patients who received a complex rehabilitation program with the addition of HIGT, there was a significant ($p<0.05$) better improvement in functioning compared to the use of only HIGT in all tests used in the research (Table 1). This indicates the absolute necessity of adding HIGT to the rehabilitation of post-stroke patients.

A comparison of the effectiveness of using a comprehensive rehabilitation program with the addition of HIGT or only HIGT in post-stroke patients at different periods after stroke was conducted (Table 2). In the L Group, the initial indicators of the control tests were better than in the E Group. This is due to the fact that Group E consisted of post-stroke patients in the acute stage (2-4 weeks), and Group L consisted of post-stroke patients in the late recovery stage (from 6 months). It is obvious that six months after an ischemic stroke, patients will already has certain results and therefore will have better initial data.

In the E Group, the use of rehabilitation programs led to significantly ($p<0.05$) better results in the recovery of patients' functioning than in the L Group. In our opinion, this is primarily due to the fact that the processes of neuroplasticity become smaller and smaller over time.

Next, an analysis of the use of a complex rehabilitation program with the addition of HIGT and the use of only HIGT was conducted depending on the start of rehabilitation programs (Table 3). The use of a complex rehabilitation program with the addition of HIGT proved to be significantly ($p<0.05$) more effective compared to the use of only HIGT both in patients in the early recovery period and in patients in the late recovery period. However, even in the late recovery stage (6-12 months), we see the effectiveness of the HIGT method in improving movement skills, increasing speed and improving balance.

DISCUSSION

The goals set in the research were achieved by the authors to a large extent. The choice of studying high-intensity training (HIGT methodology) is based on literary data about its greater effectiveness compared to low-intensity training. In particular, George T. Hornby and co-authors proved that stepping training at high intensities with or without practice of variable, difficult stepping tasks elicits gains in walking function and gait symmetry as compared lower intensity activities. Changes in balance and balance confidence suggest a possible benefit from performing complex stepping tasks during high-intensity training in variable contexts [7]. In a research by Jenifer L.

Table 1. Evaluation of the effectiveness of rehabilitation programs using HIGT

	Group 1		Group 2	
	B	A	B	A
RMI (score)	7,7 ± 0,84	11,3±1,08*^{v}	5,2 ± 1,04	10,8 ± 0,64*
BBS (score)	25,4± 1,7	40,4±3,12*^{v}	15,2 ± 1,76	31,6 ± 1,44*
10-meter walk test (m/sec)	21,5±2,24	14,6±2,12*^{v}	27,4 ± 2,08	14,2 ± 1,84*
FAC (score)	3,6±0,4	5,2±0,4*^{v}	2,6 ± 0,48	4,6 ± 0,48*
„Get Up and Go" test (sec)	36 ±3,0	24,3±2,52*^{v}	43 ± 3,2	29 ± 3,6*

**p<0,05 – verified of comparing results before and after using rehabilitation programs*

^{v}p<0,05 – verified of comparing results depending on the use of a comprehensive rehabilitation program with the addition of HIGT or only HIGT

B – before the implementation of the rehabilitation program

A – after the implementation of the rehabilitation program

Table 2. Results before and after using rehabilitation programs depending on the start of their application

	E Group		L Group	
	B	A	B	A
RMI (score)	5,3 ± 0,96	11,1±0,88*	10 ± 0,8	11,2±1,04
BBS (score)	15,1±1,68	35,4±2,4*	35,8± 1,8	41,6±2,88
10-meter walk test (m/sec)	27,1±1,96	15,35±1,88*	16,2±2,64	13,6± 2,32
FAC (score)	2,5±0,48	4,7±0,4*	4,8± 0,32	5,6 ± 0,48
„Get Up and Go" test (sec)	43,5±3,2	27,7±3,04*	28 ± 2,8	22,2± 2,56

** p<0,05 – verified of comparing results before and after using rehabilitation programs depending on the start of their application*

B – before the implementation of the rehabilitation program

A – after the implementation of the rehabilitation program

Table 3. The results depending on the application of a rehabilitation program in different recovery periods after a stroke

	1E Group		2E Group		1L Group		2L Group	
	B	A	B	A	B	A	B	A
RMI (score)	5,4 ±0,88	11,4±1,12*	5,2 ±1,04	10,8 ±0,64*	10 ±0,8	11,2±1,04*	10,2±0,96	10,7±0,92
BBS (score)	15 ±1,6	39,2±3,36*	15,2 ±1,76	31,6 ±1,44*	35,8±1,8	41,6±2,88*	35,9±1,68	40,8±2,34*
10-meter walk test (m/sec)	26,8±1,84	15,6±1,92*	27,4 ±2,08	14,2 ±1,84*	16,2± 2,64	13,6± 2,32*	16,7±1,88	13,9±2,48*
FAC (score)	2,4±0,48	4,8±0,32*	2,6 ±0,48	4,6 ±0,48*	4,8± 0,32	5,6 ±0,48*	4,6±0,4	4,9±0,38
„Get Up and Go" test (sec)	44 ±3,2	26,4±2,48*	43 ±3,2	29 ±3,6*	28 ±2,8	22,2± 2,56*	29,0±2,6	23,6±2,49*

** p<0,05 – verified of the comparison of results depending on the application of a comprehensive rehabilitation program with the addition of HIGT or only HIGT in different recovery periods after a stroke*
B – before the implementation of the rehabilitation program
A – after the implementation of the rehabilitation program

Moore and co-authors, it was demonstrated that, delivery of large amounts of stepping practice with focus on achieving higher cardiovascular intensities may result in greater locomotor performance and selected non-locomotor gains as compared with usual care during inpatient stroke rehabilitation [15]. Such data are consistent with the results of this research, in which the addition of HIGT to a comprehensive rehabilitation program demonstrated significantly greater efficacy in restoring patients' functioning both early and late after stroke.

Previously, Pamela W. Duncan and co-authors demonstrated that, locomotor training, including the use of body-weight support in stepping on a treadmill, was not shown to be superior to progressive exercise at home managed by a physical therapist [16]. In our opinion, the HIGT program, after some training of post-stroke patients, can be used at home; this can expand the circle of participants in rehabilitation programs. The same authors showed that patients who started musculoskeletal training or exercise at home had early improvements in walking and functional outcomes that were maintained at 1 year. Our research also demonstrated that the application of the HIGT program in the early period after stroke resulted to significantly ($p<0.05$) better functional changes in patients. This is due to better neuroplastic processes in the brain. According to the latest studies, patients have only 3 months to achieve the maximum from rehabilitation, then only improvement and consolidation of already acquired results in the first 3 months follows. That is why the effectiveness of any therapy depends on the beginning of its use. At the same time, it is necessary to continue the observation of patients to evaluate the results in a later period (more than a year).

Gordhan B. Mahtani with co-authors showed influence of high-intensity stepping training in variable context significant improvements in speed, symmetry, and selected sagittal-plane kinematics, although increases in compensatory strategies also were observed in people post-stroke with locomotor deficits observed [17]. In our research, the addition of HIGT to a comprehensive rehabilitation program demonstrated a significant improvement in walking speed in the 10-meter test and in the "Get Up and Go" test, although the final results of the latter remained unsatisfactory in all groups. This may indicate the need for a longer course of application of a complex rehabilitation program with the addition of HIGT.

CONCLUSIONS

On the basis of literature's data, the method of high-intensity gait training (HIGT) was chosen for the research for the rehabilitation program for middle-aged post-stroke people.

The initial functional state of post-stroke patients in the late recovery period was better than that of post-stroke patients in the early recovery period.

A HIGT training program was developed and performed by the patients in the study.

The addition of the HIGT method to a complex rehabilitation program contributes to significantly greater recovery efficiency of middle-aged post-stroke patients after an ischemic stroke.

The effectiveness of the HIGT method depended on the time of its initiation and was significantly ($p<0,05$) higher in middle-aged post-stroke persons in the early recovery period than in the late recovery period.

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ORCID AND CONTRIBUTIONSHIP*
Igor V. Kireyev: 0000-0002-5413-9273[A,E,F]
Natalia V. Zhabotynska: 0000-0003-3744-492[C-E]
Dmytro A. Andriukhin: 0009-0006-0399-8816[A,B]
Mykhailo Y. Sydorchuk: 0009-0001-7813-0302[B,C]
Karyna V. Tsemenko: 0000-0001-6319-7523[C]
Andrey L. Liashok: 0000-0003-2098-1697[B,C]

ADDRESS FOR CORRESPONDENCE
Natalia V. Zhabotynska
National University of Pharmacy
53 Pushkinska St.,
61002 Kharkiv, Ukraine
e-mail: bronkevih@gmail.com

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ORIGINAL ARTICLE

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ANALYSIS OF STATIC AND DYNAMIC BAROPEDOGRAPHIC PARAMETERS IN POST COVID-19 PATIENTS

Zofia Dzięcioł-Anikiej[1], Agnieszka Dakowicz[1], Monika Pociene[2], Janusz Dzięcioł[3], Anna Kuryliszyn-Moskal[1], Amanda Maria Kostro[1]

[1]DEPARTMENT OF REHABILITATION, MEDICAL UNIVERSITY OF BIALYSTOK, BIALYSTOK, POLAND
[2]DEPARTMENT OF PHYSIOTHERAPY AND BEAUTY THERAPY, KLAIPEDOS VALSTYBINE KOLEGIJA, KLAIPEDA, LITHUANIA
[3]DEPARTMENT OF HUMAN ANATOMY, MEDICAL UNIVERSITY OF BIALYSTOK, BIALYSTOK, POLAND

ABSTRACT

Aim: The aim of this study was to assess the parameters of the statics and dynam-ics obtained from baropodometric examinations in patients after infection with the SarsCov2 vi-rus and to attempt to identify the causes of reported gait disorders.

Materials and Methods: The study group consisted of 73 people beform COVId-19. The tested participants obtained a positive result from a PCR test confirm-ing the presence of the virus. Some people had a mild form of COVID-19. The control group consisted of 50 healthy people. The test was carried out on a FreeMed Posture baropodometric mat in static and in dynamic conditions while walking.

Results: Statistically significant differences were obtained in the assessment of parameters such as the foot area, the average load on the lower limbs, the maximum load on the lower limbs in the dynamic assessment, as well as differences in parameters for the load on the forefoot and for the rear foot. On the other hand, in the static assessment, significant differences between the groups were found for the parameters of the foot surface , including the area of the hindfoot.

Conclusions: In patients with a history of COVID-19, there may be gait disturbances in the baropodometry test that are visible in the load on the lower limbs and the surface of the feet. This may suggest a weaker efficiency of the foot muscles, which are responsible for its arching, and stronger pressure during walking and standing may be associated with a weaker nervous control of the muscles responsible for foot functions.

KEY WORDS: COVID-19, gait, analysis, coronavirus

INTRODUCTION

During the course of SarsCov2 infection, disorders in the functioning of many or-gans and systems have been observed. Numerous reports have presented descriptions of these disorders, including dysfunctio ns of the lungs and circulatory system and haematological and neurological disorders [1, 2].

Although the disease process most often involves the respiratory system, it can also involve the nervous system and lead to neurological symptoms and disorders. The current data have revealed that neurological symptoms, including seizures and cere-brovascular events, can lead to long-term symptoms known as long COVID [3].

Fatigue is often observed in long COVID patients, followed by memory impair-ment, sleep disturbances, and so-called "brain fog" [4]. The consequences of being ill with COVID-19 also include the frequent disorders of neuromuscular connections, which are characterized, among others, by neuropathies and muscle damage [1, 5].

Many neurological symptoms that are associated with COVID-19 infection have been described. The most common symptoms include headache, Guillain-Barré syndrome, and Miller-Fisher syndrome [6]. Polyneuropathy has been observed in some patients after COVID-19. It occurs, among others, in the form of the Guillain–Barré syndrome (GBS). GBS is 5 to 13.5 times more likely to be observed in people with a his-tory of COVID-19 than in the population of people without infection caused by the SarsCov2 virus [7, 8]. GBS is a post-infectious neuropathy that is caused by an immune response against the peripheral nerves. In the clinical picture of the syndrome, weak-ness of the limb muscles, impaired sensation, and tendon reflexes, as well as impaired gait functions, are observed. The observed disorders in patients after COVID-19 are similar to those in the classic form of GBS [1, 9].

Myositis caused by the SarsCov2 virus can also affect gait. Pain in patients with myositis may cause weakness of the proximal muscles of the lower limbs and lead to gait impairment and, consequently, increase the risk of falls after COVID-19. There may also be a bilateral deficiency in assessing hip flexions [5, 10].

Gait abnormalities caused by musculoskeletal disorders may not only be an indi-rect effect of inflammatory and/or immune responses but may also result from direct damage

to the endothelial vessels or peripheral nerves by the SarsCov2 virus [11].

Gait is the basic function of locomotion. It is controlled by a complex neuromotor system and is a skill that provides information about the interaction of musculoskeletal units with other internal systems [12]. Reports have described the occurrence of neuro-logical damage after COVID-19, which can affect gait by impairing cerebellar coordination [13].

A cohort study by Mehan W.A et al. on 641 patients with COVID-19 showed that in order to determine the cause of spinal pain, lower limb muscle weakness, and par-aesthesia which was occurring in nine patients, there was a need to perform an MRI test. None of these patients had previously been treated for inflammation and other muscle disorders. In 7 out of 9 (78%) patients, spinal MRI showed bilateral extensor and multifidus inflammation [5, 14].

Patients requiring hospital rehabilitation after suffering from COVID-19 often show deficits in mobility, cognitive functions, speech, and swallowing. These disorders in some people also persist after rehabilitation [15]. The musculoskeletal complaints reported by people after COVID-19 have included muscle and joint pain, as well as ex-treme fatigue [1, 16-18]. Muscle weakness may also result from limited physical activity during COVID-19 infection, and, in some patients this could be the effect of the therapy used. In extreme cases, muscle weakness and atrophy can occur, resulting in the impaired efficiency of the entire musculoskeletal system [19, 20].

Baropodometry is a method that has been used to measure the distribution of foot loads during statics and dynamics [21, 22]. In different types of feet-normal, flat, and hollow-foot differences in the changed angles of the frontal and transverse planes on the rear part of the foot and in the hollow foot have been observed with less metatarsal movement in the hollow foot during initial contact and a reduced range of motion in the frontal metatarsal plane of the flat foot during the pre-foot phase swing [23].

These results indicate that foot types affect gait stability [24]. Flat feet show high-er scores for peak pressure, total pressure over time, maximum force, total force over time, and contact area, mainly in the medial arch, medial forefoot, and big toe. These variables are lower in the lateral and medial regions of the forefoot.

In comparison with hollow feet, they show a higher peak and total pressure over time at the heel and lateral forefoot, while pressure over time, maximum force, the in-tegral of force over time, and contact area are lower in the metatarsal and toe area. In addition, the overall center of pressure can be deflected laterally in hollow feet and more medially in flat feet [25].

Walking speed is another parameter that also affects the plantar pressure of the foot. Research results have shown that walking speed significantly affects the peak pressure gradient ($p < 0.05$), and its dynamic patterns are defined as the pressure gradient angle ($P < 0.05$) [26]. No effect of walking duration on these parameters was observed. In addition, as the patient's appropriate walking speed increased, the median peak forefoot pressure and total pressure over time increased ($p < 0.001$), while the heel and lateral forefoot areas showed a change in plantar pressure. These results sug-gest less (heel strike) or more evenly distributed (push) loads at a certain walking speed [27]. In addition, intrinsic foot muscle activity has also been observed to increase with increasing load and postural demands, meaning that, during walking, the distri-bution of the vertical reaction force of the plantar bed results in greater muscle tension in people with flat feet, while a slower rate of change in the plantar surface of the foot provides greater stability in people with a higher longitudinal arch [28, 29]. In addition, there are also differences in the assessment of baropodometric parameters in the gait of patients with dysfunctions within the nervous system [22, 30, 31] and the musculo-skeletal system, not only in the dynamic form but also when static [32-35]. In addition, the variability of foot pressure on the ground in patients can be observed with balance disorders as well as an improvement in their indicators after using exercises involving deep muscles [36-38].

The structure and function of the foot are also affected by body weight, which causes a change in the load on the feet, as well as the correct displacement of the cen-ter of gravity; this can cause a change in gait. In people with increased body weight, stability disorders can also occur, which increases the risk of falling [39]. Patients with high body mass index (BMI) values are at high risk of contracting COVID-19 and have higher disease activity, worse response to treatment, and are more frequently observed with a disability [40, 41].

Only a few studies indicate coordination disorders and gait impairment in pa-tients after COVID-19. The determination of static and dynamic disorders in these pa-tients may be of significant prognostic importance in terms of planning care for these patients, indicating the need to continue research in relation to the functional assess-ment of patients [42].

AIM

The aim of this study was to assess the parameters of the statics and dynam-ics obtained from baropodometric examinations in patients after infection with the SarsCov2 vi-rus and to attempt to identify the causes of reported gait disorders.

MATERIALS AND METHODS

The research was conducted at the Rehabilitation Clinic with the consent of the Bioethics Committee No. APK.002.51.2022. Each of the patients gave their voluntary consent to participate in the study and was in-formed about the results and the course of the study.

The study group consisted of 73 people (42 women and 31 men) aged 24 to 75 (mean age 48), with an average BMI of 28.91. All tested patients had experienced a mild form of COVID-19 with saturation from 93% to 98% (average 95%). The tested partici-pants obtained a positive result from a PCR test, confirming the presence of the virus. The studies

were conducted 4-6 months after the end of treatment.

The control group consisted of 50 healthy people (29 women and 21 men) aged 22 to 72 (mean age 44), with an average BMI of 25.18. The study group was tested before the start of the COVID-19 pandemic, which confirmed that some people did not suffer from COVID-19 even asymptomatically.

Exclusion from the study included people who had coexisting diseases impairing their gait and balance, such as neuromuscular diseases, neurological deficits, sensory disturbances, pain and injuries of the lower limbs, a lack of independent mobility or the use of assisted devices such as crutches or canes. The people taking part in the study also showed no difference in the length of their lower limbs.

Both the study group and the control group were residents of Poland from the Podlaskie Voivodeship, which indicated a similar demographic structure in the study group. The characteristics of the studied groups are presented in Table 1 and Figure 1.

The test was carried out on a FreeMed Posture version 1.3.5 baropodometric mat in dynamic conditions-during locomotion, while static, and when standing-using the same device in the same environmental conditions at the same time of day.

The dynamic assessment consisted of walking to a certain distance by each tested participant on a strain gauge platform while measuring foot pressure on the ground. In the dynamic assessment, parameters were compared separately for the right and left foot, including the footprint length (mm), gait length line (mm), foot surface area (mm2), maximum and average load (g/cm2), as well as the load in individual parts of the foot, including the medial, lateral, forefoot and hindfoot (%).

The static assessment consisted of measuring pressure in the feet on the ground during 5 seconds of standing in a physiological position. The following parameters were assessed: the foot area divided into the forefoot and hindfoot (cm2), the foot load divided into the forefoot and hindfoot (%), the maximum and average foot load (g/cm2), the location of the center of gravity in relation to the X coordinates (coefficient CoP X) and Y (CoP Y coefficient), as well as the location of the foot pressure center in the coordinate system for the right foot in the X axis (CoF RF X) and the left foot (CoF LF X coefficient), alongside the location relative to the Y axis for the right foot (CoF RF Y coefficient) and the left foot (CoF LF Y coefficient).

STATISTICAL ANALYSIS

All variables evaluated in this study were of the quantitative or ordinal type. Comparisons between the independent subgroups were conducted using the Mann-Whitney test, while comparisons before and after the pandemic were made using the Wilcoxon rank sum test. All calculations were performed using IBM SPSS Statistics 27.0 software. Statistical hypotheses were tested at a significance level of $p < 0.05$.

RESULTS

In the dynamic assessment of the right foot, the length of the footprint between the study group and the control group did not show statistically significant differences for the left foot (LF) ($p = 0.843$) or for the right foot (RF) ($p = 0.693$) (Table 2).

In the assessment of the gait length line for the right and left feet, no statistically significant differences were found (Table 3). Taking into account the reflection surface of the feet while walking, a difference was found for both the left ($p < 0.001$) and the right foot ($p = 0.001$) between patients with COVID-19 and the control group (Table 4).

Table 1. BMI in each group

Group	n	Average	SD	Minimum	Q1	Median	Q3	Maximum
Control group	50	25,18	5,13	18,44	21,44	23,75	27,17	38,37
COVID-19 Group	73	28,91	4,68	20,88	25,42	28,35	31,79	41,03

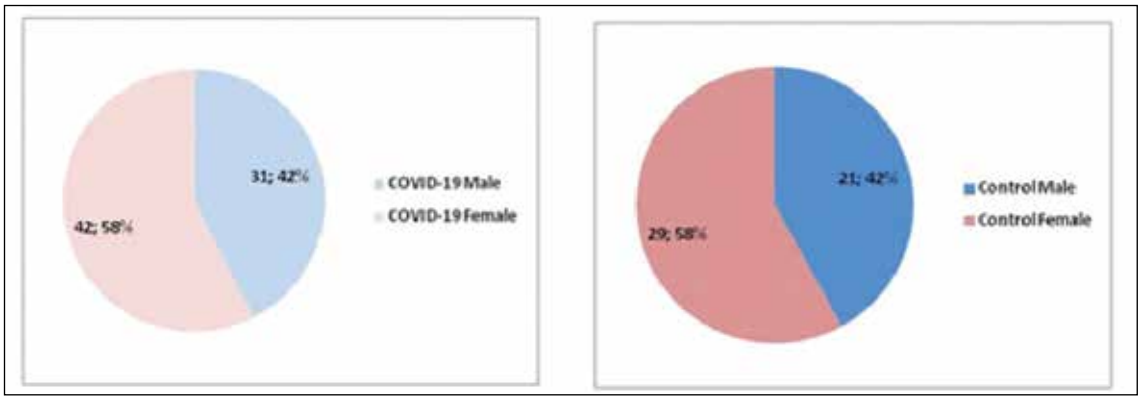

Fig. 1. Percentage distribution of patients in the study group by gender

Table 2. Comparison of dynamic results for the footprint length parameter of the left (LF) and right (RF) foot between the control and study groups

Parameter	Group	Average	SD	Min	Q1	Median	Q3	Max	p
LF footprint length mm	CONTROL	251,44	19,89	200,23	240,00	250,00	263,03	300,52	0,843
	COVID-19	250,91	21,25	194,63	234,03	249,58	263,53	308,18	
RF footprint length mm	CONTROL	251,06	19,29	200,19	240,00	250,00	260,00	310,45	0,693
	COVID-19	252,93	24,46	194,08	234,38	250,57	264,79	341,97	

Table 3. Comparison of dynamic results for the gait length of the left (LF) and right (RF) foot between the control and study groups

Parameter	Group	Average	SD	Min	Q1	Median	Q3	Max	p
LF gait length mm	CONTROL	221,11	20,32	164,00	210,02	221,50	236,00	256,00	0,112
	COVID-19	212,75	29,17	60,21	200,13	215,00	235,13	255,05	
RF gait length mm	CONTROL	217,27	24,58	101,00	210,25	218,00	233,11	251,00	0,554
	COVID-19	216,01	25,78	139,28	200,13	215,52	235,21	270,60	

Table 4. Comparison of dynamic results for the left (LF) and right (RF) plantar surface between the control and study groups

Parameter	Group	Average	SD	Min	Q1	Median	Q3	Max	P
LF plantar surface cm^2	CONTROL	103,76	20,85	63	91,5	102	114,5	154	0,000
	COVID-19	117,14	18,70	62	103,5	116	128,5	157	
RF plantar surface cm^2	CONTROL	165,72	429,69	68	88,75	105,5	118	3140	0,001
	COVID-19	118,30	21,14	69	98,5	120	132	167	

Table 5. Comparison of dynamic results for the maximum and average pressure of the left (LF) and right (RF) foot between the control and study groups

Parameter	Group	Average	SD	Min	Q1	Median	Q3	Max	P
LF max pressure gr/cm^2	CONTROL	3381,36	623,57	2036	2928	3376	3693	4864	0,003
	COVID-19	3081,52	467,01	2108	2774	3052	3384	4216	
RF max pressure gr/cm^2	CONTROL	3207,98	680,93	1135	2912	3142	3578	4636	0,030
	COVID-19	2999,12	442,69	2188	2706	2924	3344	4684	
LF average pressure gr/cm^2	CONTROL	1109,82	177,90	745	952	1106	1228	1634	0,001
	COVID-19	1003,89	157,00	755	868,5	993	1091	1494	
RF average pressure gr/cm^2	CONTROL	1061,04	180,29	677	933	1064,5	1177	1420	0,001
	COVID-19	960,19	158,74	664	849	969	1054	1490	

Statistically significant differences in both the maximum and average foot loads during walking were demonstrated. The maximum load for the left foot was statistical-ly lower in patients with COVID-19 compared to the control group (Table 5).

The percentage load on the right and left foot, as well as the load on the right hindfoot and left foot ($p < 0.001$), showed a statistically significant increase in values for patients with COVID-19 compared to the control group. No statistically significant differences were obtained in the comparison between the study group and the control group in the parameters of medial and lateral loads on the right and left sides (Table 6).

Different statistical results were obtained when assessing the static parameters.

Statistically significant differences were obtained in the foot surface parameter of the left ($p = 0.006$) and right ($p = 0.013$) patients with COVID-19 compared to the control groups.

There were no statistically significant differences in the surface of the left ($p = 0.103$) and right ($p = 0.171$) forefoot. However, a statistically significant difference was obtained for the surface of the left ($p = 0.001$) and right ($p < 0.001$) hindfoot (Table 7). When comparing the study groups, participants from the study group showed higher average results for all parameters when determining the surface area of the feet.

Table 6. Comparison of dynamic results for forefoot and hindfoot pressure, as well as medial and lateral plantar pressure between the control and study group

Parameter	Group	Average	SD	Min	Q1	Median	Q3	Max	P
LF forefoot pressure %	CONTROL	60,64	6,99	40	56,75	60,5	65	78	0,000
	COVID-19	54,51	9,41	24	49,5	54	60,5	75	
RF forefoot pressure %	CONTROL	60,44	8,69	30	55,75	61	65	80	0,000
	COVID-19	52,58	10,21	16	48	53	58	78	
LF hindfoot pressure %	CONTROL	39,36	6,99	22	35	39,5	43,25	60	0,000
	COVID-19	45,49	9,41	25	39,5	46	50,5	76	
RF hindfoot pressure %	CONTROL	39,20	7,72	20	35	39	44,25	56	0,000
	COVID-19	47,42	10,21	22	42	47	52	84	
LF medial pressure %	CONTROL	50,04	9,74	26	43,75	50,5	55,25	86	0,381
	COVID-19	48,52	8,54	25	44	49	53	80	
RF medial pressure %	CONTROL	49,74	10,72	14	46,75	52	55	70	0,722
	COVID-19	49,79	8,73	15	45	51	56	67	
LF lateral pressure %.	CONTROL	49,70	9,86	14	44	49	56,25	74	0,289
	COVID-19	51,48	8,54	20	47	51	56	75	
RF lateral pressure %.	CONTROL	49,88	11,44	20	45	48	53,25	86	0,711
	COVID-19	50,21	8,73	33	44	49	55	85	

Table 7. Comparison of the static results for the forefoot and hindfoot surface of the left (LF) and right (RF) foot between the control and study groups

Parameter	Group	Average	SD	Min	Q1	Median	Q3	Max	P
LF plantar surface cm^2	CONTROL	69,58	21,92	33	53,5	64	82,25	128	0,006
	COVID-19	81,16	25,43	34	63	79	93	176	
RF plantar surface cm^2	CONTROL	75,04	26,97	30	52,75	71,5	89,25	158	0,013
	COVID-19	87,21	28,01	44	64,5	87	105,5	194	
LF forefoot surface cm^2	CONTROL	36,08	15,95	6	23	33	46,5	76	0,103
	COVID-19	41,40	17,74	12	30	41	50,5	113	
RF forefoot surface cm^2	CONTROL	41,48	18,57	6	25,75	41	49,25	86	0,171
	COVID-19	46,41	19,27	17	30,5	46	57,5	114	
LF hindfoot surface cm^2	CONTROL	33,56	8,35	20	27	32	39,25	56	0,001
	COVID-19	39,74	10,58	17	33	39	46	72	
RF hindfoot surface cm^2	CONTROL	33,66	10,37	18	25,75	30,5	41	73	0,000
	COVID-19	40,74	10,20	23	34	41	45,5	80	

Table 8. Comparison of static results for maximum and average plantar pressure of the left (LF) and right (RF) foot between the control and study groups

Parameter	Group	Average	SD	Min	Q1	Median	Q3	Max	P
LF max. plantar pressure gr/cm^2	CONTROL	1244,54	347,73	614	991	1183,5	1473	2378	0,726
	COVID-19	1256,85	316,31	483	1029,5	1240	1434	2063	
RF max. plantar pressure gr/cm^2	CONTROL	1271,54	317,61	754	1014	1257,5	1506	1983	0,750
	COVID-19	1252,51	309,63	643	1033	1219	1432,5	2104	
LF av. plantar pressure gr/cm^2	CONTROL	518,82	139,29	320	410	498	615	1015	0,562
	COVID-19	529,44	133,50	241	424,5	521	615,5	902	
RF av. plantar pressure gr/cm^2	CONTROL	549,14	143,36	336	441	533,5	624	950	0,200
	COVID-19	515,99	125,77	276	430	496	568	894	
	COVID-19	515,99	125,77	276	430	496	568	894	

Table 9. Comparison of static results for the CoF for the X and Y coordinates of the left (LF) and right (RF) foot between the control and study groups

Parameter	Group	Average	SD	Min	Q1	Median	Q3	Max	P
CoF LF X	CONTROL	6,36	2,04	4,02	5,35	5,91	6,67	14,44	0,627
	COVID-19	6,07	0,97	3,98	5,40	6,11	6,68	8,00	
CoF LF Y	CONTROL	17,77	2,57	11,51	16,04	18,06	18,97	26,40	0,417
	COVID-19	17,37	2,63	11,87	15,76	17,13	19,21	24,80	
CoF RF X	CONTROL	23,69	3,80	14,64	21,16	24,18	26,35	31,88	0,169
	COVID-19	22,89	3,51	15,36	19,89	23,24	25,15	30,86	
CoF RF Y	CONTROL	17,47	2,69	13,35	15,66	17,25	18,35	27,26	0,928
	COVID-19	17,26	2,36	12,43	15,38	17,53	18,95	23,33	

Table 10. Comparison of static results for the CoP for the X and Y coordinates of the left (LF) and right (RF) foot between the control and study groups

Parameter	Group	Average	SD	Min	Q1	Median	Q3	Max	P
CoP X	CONTROL	15,59	3,09	7,55	13,60	15,82	17,64	24,41	0,061
	COVID-19	14,66	2,33	9,76	13,28	14,45	16,41	19,98	
CoP Y	CONTROL	17,63	2,48	12,65	15,78	17,45	18,66	26,92	0,614
	COVID-19	17,35	2,30	12,87	15,69	17,12	18,82	23,98	

Static loading showed no significant differences between the groups for the max-imum left (p = 0.726), right foot (p = 0.75), and mean left (p = 0.562) and right foot (p = 0.2) loads (Tables 7, 8).

Statistical significance was also not demonstrated for the parameters of the CoF coefficient for the left foot in relation to the X (p = 0.0627) and Y (p = 0.417) coordinates or the right foot for the X (p = 0.169) and Y coordinates (p = 0.928) (Table 8). Similarly, there were no significant differences between the groups for the CoP of the X (p = 0.061) and Y (p = 0.614) coordinates (Tables 9, 10).

DISCUSSION

A variety of rehabilitation programs can be offered to post-COVID patients based on particular physical training. This is due to the fact that approximately 90% of pa-tients have impaired standing, stability, and spatial orientation. This can have a signifi-cant impact on the patient's gait and mobility. The aim of the study conducted by Lobanov et al. was to evaluate the effectiveness of water exercise techniques in im-proving the health of COVID-19 patients. This study showed the beneficial effect of exercise on a reduction in body axis deviation, head oscillation, and body mass center, as well as the direction of the body motion vector recorded in objective gait analysis. The obtained results were confirmed by the patient's subjective feeling of reduced in-stability experienced with their gait. Reducing the amplitude of deviations in the body axis in all three planes may be associated with an improvement in the blood supply to the areas of the brain responsible for the coordination of motor functions and balance. The results of these studies suggest that patients after COVID-19 infection have dis-turbances in gait coordination. These disturbances can be described by determining the oscillation of the center of gravity. The water exercise technique developed by the au-thors seemed to contribute to the restoration of disturbed vertical posture and motor functions, normalizing the gait pattern [43].

In this study, in an assessment of the oscillation of the center of gravity between the study group and the control group during the static assessment, no differences were found in the parameters at the location of the center of gravity in relation to the X (CoP X) and Y (CoP Y) coordinates, as well as in the location of the center of the foot pressure in the coordinate system for the right foot in the X axis (CoF RF X) and left foot (CoF LF X) alongside a position relative to the Y axis for the right foot (CoF RF Y) and the left foot (CoF LF Y coefficient). A study by Cevei et al. assessed the benefits of early and targeted rehabilitation using combined methods and robotic medical devices along with other manual techniques and rehabilitation therapies in elderly people after an acute course of COVID-19. Ninety-one patients were evaluated. In all the partici-pants, except for one case who underwent gait improvement with a Lokomat after the therapy session, there was an improvement in walking speed, the ability to maintain body posture, and the distance covered. The test enabled a continuous display of the average percentage change (increase/decrease) in the analyzed parameters. As a result of automatic gait re-education, there was also an improvement in the mobility of the hip and knee joints [20].

This study evaluated foot disorders in static and dynamic conditions and showed statistically significant differences between the study group and the control group. This

applied in particular to the dynamic assessment of the foot surface area (mm2), the maximum and average load (g/cm2), as well as the load in individual parts of the foot, including the forefoot and rearfoot (%). Differences between these groups also occurred in the assessment of the static parameters of the foot surface while taking in-to account the hindfoot (cm^2).

Patients, after contracting COVID-19, showed a problem with their ability to maintain mobility. This was confirmed by the Time up and Go gait test in the presence of a cognitive task called the Dual Task. According to Morella, patients with COVID-19 show worse outcomes compared to patients with chronic lung diseases who do not suffer from COVID-19 [44].

An assessment of plantar foot pressure measurements has provided information on foot function during gait and other functional activities. This is because the foot provides the necessary support and flexibility to bear the weight of the body while walking. Foot dysfunctions may be observed in diabetic patients with peripheral neu-ropathy. Therefore, in our study, patients with these diseases were excluded from the study group.

Baropodography provides important information that can also help define reha-bilitation and treatment programs for impairments that relate to musculoskeletal and neurological disorders. The variables that comprised the subject of our assessment – peak and average pressure, force, and foot pressure area – are important for determin-ing the degree of disorder and the direction of physical rehabilitation. Peak pressures are often of interest in determining the effectiveness of foot cushioning in reducing pressure, while mean pressures also allow clinicians to understand the typical pres-sure applied to a particular anatomical region during the gait cycle. The foot area can be measured as the contact area between the plantar surface of the foot and the sensor. The size of the force or pressure, when applied over time, allows the assessment of the duration or contact of the foot with the ground [45]. Therefore, baropodographic pa-rameters may seem helpful when planning the rehabilitation of patients after a COVID-19 infection.

The values of baropodographic parameters show individual variability. They can be influenced by factors such as gender, age, and BMI. This is confirmed by the data presented in the literature, where a meta-analysis of the literature allowed us to draw similar conclusions [46]. Gender affects the size and shape of the foot. Women's and men's feet differ mainly on the lateral side of the foot, the arch of the foot, the metatar-sus, and the big toe. It has been shown that these differences can cause changes in the distribution of foot pressure in men and women when standing. Men have a larger foot contact area and pressure distribution than women. Additionally, men have shown a larger contact area in all regions compared to women. There was no differ-ence in the peak blood pressure between the sexes in any region [47].

The factor that affects the values of plantar pressure is also the patient's BMI. An increased BMI can result in an increased total contact area and total surface area when compared to those with a lower BMI [47]. The height of the arch of the foot and the thickness of the plantar fascia was significantly higher in the obese group compared to the group with normal body weight [48]. In addition, obese people have a higher rate of peak sole pressure in the forefoot area compared to the heel [49].

Age is another factor that affects the plantar pressure of the foot. Studies have found that there is a reduction in pressure under the heel, midfoot, and toe with age [46]. Medial pressure and force values are lower in older people than in younger peo-ple. Older people also tend to put more lateral pressure on their foot. In addition, the elderly have shown a decrease in the maximum pressure and force measured under pressure for the hindfoot regions and forefoot, as well as a reduced contact time in the midfoot compared to younger patients [37]. These parameters change if another factor is imposed on them, e.g., body weight. It has been shown that overweight and obese elderly women have greater loads on the plantar side of the foot [40]. In addition, older people with forefoot pain generate higher peak plantar pressures under lateral meta-tarsal heads when walking. Other factors may be responsible for an observed increase in pressure, such as a reduced range of motion in the metatarsophalangeal joints and the increased stiffness of plantar soft tissues [41]. Additionally, taking into account a younger age and higher body weight, studies have shown that overweight and obese children show significantly higher peak pressures and peak forces, and significantly higher force-time integrals and pressure-times under the II-V metatarsals [42].

CONCLUSIONS

The conducted study shows that in people with a history of COVID-19 infection, there are differences in the parameters of foot pressure redistribution when assessed on a baropodometric platform, both in static and dynamic tests. The diagnostic method used in this study allowed for a quick and accurate gait measurement and could be an excellent source of comparison in relation to the results before and after the applied forms of therapy.

A baropodometric examination has been shown to constitute a useful diagnostic tool for the assessment and monitoring of gait.

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ORCID AND CONTRIBUTIONSHIP*

Zofia Dzięcioł-Anikiej: 0000-0001-5139-2321[A,D,F]
Agnieszka Dakowicz: 0000-0002-5873-1709[B,C]
Monika Pociene: 0000-0001-9681-0232[C]
Janusz Dzięcioł: 0000-0002-7193-5693[A,E]
Anna Kuryliszyn-Moskal: 0000-0001-5287-0401[C]
Amanda Maria Kostro: 0000-0002-9544-168X[C,D]

ADDRESS FOR CORRESPONDENCE

Zofia Dzięcioł-Anikiej
Department of Rehabilitation,
Medical University of Bialystok
24A, M. Skłodowskiej-Curie St., 15-089 Bialystok, Poland
e-mail: dzieciol.zofia@gmail.com

CONFLICT OF INTEREST

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STAGED REHABILITATION OF MILITARY PERSONNEL AS PART OF A MULTIMODAL APPROACH TO THE GUNSHOT SOFT TISSUE DEFECTS RECONSTRUCTION

Igor A. Lurin[1,2], Igor P. Khomenko[2], Olena A. Gozhenko[3], Volodymyr V. Nehoduiko[4,5], Oleh S. Herasimenko[6], Serhii V. Tertyshnyi[6], Evgeny O. Grigoriev[7]

[1]NATIONAL ACADEMY OF MEDICAL SCIENCES OF UKRAINE, KYIV, UKRAINE
[2]STATE INSTITUTION OF SCIENCE «RESEARCH AND PRACTICAL CENTER OF PREVENTIVE AND CLINICAL MEDICINE» STATE ADMINISTRATIVE DEPARTMENT, KYIV, UKRAINE
[3]SE "UKRAINIAN RESEARCH INSTITUTE OF TRANSPORT MEDICINE" OF THE MINISTRY OF HEALTH OF UKRAINE, ODESA, UKRAINE
[4]MILITARY MEDICAL CLINICAL CENTER OF THE NORTHERN REGION, KHARKIV, UKRAINE
[5]KHARKIV NATIONAL MEDICAL UNIVERSITY, KHARKIV, UKRAINE
[6]MILITARY MEDICAL CLINICAL CENTER OF THE SOUTHERN REGION, KHARKIV, UKRAINE
[7]INTERNATIONAL EUROPEAN UNIVERSITY, KYIV, UKRAINE

ABSTRACT

Aim: To increase the efficacy of the original staged scheme of wounded with soft tissues gunshot defects (STGD) rehabilitation using the original improvement of diagnostic and restorative rehabilitation measures.

Materials and Methods: The wounded with STGD were admitted to the Military Medical Clinical Center of the Southern Region (Odesa). The wounded were randomized in three groups depending on the severity of the injury for further rehabilitation in sanatorium-resort conditions. Spectral infrared thermography diagnostic capabilities were used to control the efficacy of rehabilitation measures and to evaluate the rehabilitation prognosis.

Results: The data obtained were divided into immediate clinical and delayed organizational ones with rapid implementation into the medical practice to support the military forces of Ukraine. Authors showed the full-fledged functional recovery of the patient's injured limbs as a result of original step-by-step scheme applying of providing medical care in cases of STGD.

Conclusions: Timely rehabilitation measures at all stages of providing medical care in the Armed Forces are faster and more effective. The organizational and methodological foundations of the staged rehabilitation system of wounded servicemen with STGD at different levels of medical care depending on the severity of the injury and the tactics of surgical treatment have been developed. Different three- and four-staged models of rehabilitation measures for the injured with different severity have been proposed.

KEY WORDS: soft tissues gunshot defects reconstruction, surgical treatment, staged rehabilitation, treatment efficacy, rehabilitation, multimodal concept

INTRODUCTION

Rehabilitation of military personnel after lower extremities soft tissue gunshot wounds defects is a common and challenging problem for surgical and rehabilitative teams [1]. The process of soft tissues gunshot defects (STGD) reconstruction is multi-staged and requires a number of operative interventions in different periods of time at different levels of medical care [2]. Rehabilitation measures for such patients are also different. Currently, medical assistance to military personnel is four-level. Each level has its own amount of medical assistance [2, 3].

The first level of medical support is formed and implemented at the tactical level for the expense of the battalion's medical service, forces and means and provides the first medical (pre-medical) and first medical aid.

The second level of medical support is formed and implemented at the tactical level for the expense of the brigade medical service, forces and means and provides the qualified medical assistance. Therefore, rehabilitative measures at the first and second levels are actually not provided, are not expedient and not of primary importance.

The third level of medical support is formed and implemented at the operational level for the expense of military mobile hospitals and stationary military or civilian health care facilities deployed within the operational zone, and provides the qualified and specialized medical care. At this level, rehabilitation assistance is provided in the acute period. If the goal cannot be achieved, the injured person is transferred to the fourth level of medical care.

The fourth level is formed and implemented at the strategic level for the expense of military medical clinical centers, state and communal health care facilities and provides the highly specialized medical care using high-tech equipment and/or high complexity specialized medical procedures. This level of medical support is the place where the goal and task of rehabilitation of the wounded must be fully realized. At this level, rehabilitation care is provided in acute, post-acute and postponed long-term rehabilitation periods in inpatient and outpatient conditions.

Rehabilitation measures in sanatorium-resort conditions in the post-acute and long-term rehabilitation periods of wounded servicemen are implemented exclusively in sanatorium-resort facilities of the Armed Forces [4] which include the sanatorium department of the Military Medical Clinical Center of the Southern Region.

Certain time we have been actively improving the medical and physiotherapeutic method of providing medical, including highly specialized, home care to victims with soft tissues gunshot wounds which provides an opportunity to report certain original ideas and achievements [3, 5].

AIM

The aim of the present work was to increase the efficacy of the original staged scheme of wounded with soft tissues gunshot defects rehabilitation using the original improvement of diagnostic and restorative rehabilitation measures.

MATERIALS AND METHODS

According to the statistical analysis of the nature of injuries in the wounded who were admitted to the Military Medical Clinical Center of the Southern Region (Odesa), in the structure of sanitary losses of the surgical profile, the specific weight of wounded with STGD is 16.7%.

The anatomical and functional characteristics of STGD localization were as follows: chest – 14.0%, abdomen – 7.0%, pelvis – 4.1%, limbs – 74.9%. In the STGD structure extra-large injuries made up 6.1%, large – 33.7%, medium – 60.2%.

Clinical-epidemiological and clinical-anatomical studies proved that 36.8% of STGD wounded had a mild combat surgical injury, 45.7% – severe, and 17.5% – extremely severe.

The cause of STGD in 45.6% of servicemen was shrapnel wounds, bullet wounds in 38.0%, mine-explosive wounds in 16.4%. Isolated combat surgical injury was found in 28.9% cases, multiple – in 44.2%, combined – in 26.9% of wounded with STGD.

Impenetrable combat surgical trauma was diagnosed in 62.9% of the wounded, penetrating into the pleural cavity – in 17.4%, into the abdominal cavity – in 16.3%, into the pelvic cavity – in 3.4% of servicemen.

Using the abovementioned statistical calculation, we randomized patients on the following three groups for further rehabilitation in sanatorium-resort conditions (Admission Trauma Scale (AdTS) index was used to assess the severity of injuries) [6]:

The 1st group – wounded with a mild injury (medium-sized STGD, AdTS <5 points, perfusion index >4%) after a full volume of surgical care with primary and final correction of the injury;

The 2nd group – wounded with severe trauma (large-sized STGD, AdTS 5-9 points, perfusion index 2-4%);

The 3rd group – wounded with extremely severe trauma (extra-large STGD, AdTS >9 points, perfusion index <2%).

Spectral infrared thermography diagnostic capabilities were used to control the efficacy of rehabilitation measures and to evaluate the rehabilitation prognosis.

RESULTS

For the 1st group wounded servicemen we developed a three-staged model of rehabilitation when the wounded began rehabilitation measures in the acute period in a hospital (stage I) and, upon reaching certain conditions, were immediately transferred to a specialized department of a sanatorium-resort facility (stage II with 21 days duration) and, if necessary, to the outpatient stage of rehabilitation (III stage with 14 days duration). Our diagnostic, clinical and rehabilitative measures optimization resulted in 94% wounded of this group return to military service after early sanatorium-resort rehabilitation.

We have proposed a four-staged model of rehabilitation for the wounded of the 2nd group. We propose to divide the sanatorium-resort rehabilitation stage (II stage) into an early sanatorium, which is provided in the post-acute rehabilitation period and, accordingly, consists of two parts (the stage of reconstructive surgical interventions with 10 days, and the stage after the final surgical reconstruction with 12-14 days duration), and delayed (not mandatory), which is provided in the long-term rehabilitation period, in particular, in cases of complications development, for example, scar contractures, keloid scars, etc.

The wounded of the 3rd group also received rehabilitation treatment according to the four-staged model. Their rehabilitation potential was additionally considered at the outpatient stage (III stage) and doctors of the military medical commission made decisions about the possibility of their further military service. The terms of such patients' referral to rehabilitation stages were longer.

We have diversified and optimized the inpatient stage of rehabilitation to make it more effective. We suppose to resolve the following problems on this stage: pain reduction; the inflammatory exudates volume reducing; tissues metabolic needs reduction; affected tissues protection from further damage; protection of tissues formed from tearing; ensuring the new tissue growth and fibers restoration; maintaining the cardiovascular and muscle-skeletal systems normal functional activity; infectious complications development preventing, etc.

Medication treatment is prescribed to prevent postoperative complications. The PRICE principle is applied for the patients in the early stages (up to 72 hours after surgical treatment) after soft tissue injuries management: Protection; Rest; Ice; Compression (to reduce the volume of exudates and pain); Elevation (to reduce bleeding, swelling, pain) [7].

2-3 days after the surgery (when the stage of tissue proliferation begins) we fulfilled the following tasks of rehabilitation: pain reduction; edema reduction; local temperature decreasing; further tissue damage prevention; newly formed tissues protection; muscle strength and

coordination both support and enhancement; the functions improvement.

We used a basic complex of therapeutic gymnastics (TG), breathing exercises in the initial position lying on the back is prescribed; the patient is verticalized. On the 3rd – 4th day the patient performs the basic TGcomplex and breathing exercises in the initial position lying on his back and sitting; sitting in bed with the lower limbs lowered from it, therapeutic dosed walking (TDW) with additional support (walkers, crutches) with limitation of axial load on the injured limb within the ward is allowed. Massage of the upper extremities is prescribed throughout the 4th till 5th day.

The basic TG complex is expanded due to the increase in repetitions, the duration of classes and the variety of the starting position. Exercises are prescribed to preserve the range of motion in the injured limb. The main limitation for expanding the range of active and passive movements is pain. The limitation of axial load on the injured limb is maintained.

It is important to assign physical loads along the functional load lines, which are normally characteristic of one or another tissue. This will contribute to the structuring of collagen fibers, which are aligned along the line of application of the load. Starting from the 6th day we allowed to increase the level of loads, which is due to the formation of a sufficiently large layer of fibrous tissue.

Physiotherapy treatment is extended by electrotherapy, laser therapy, etc. Psychotherapy sessions are also provided with the wounded.

While prescribing the hardware physiotherapy methods we used a syndromic-pathogenetic approach with the dominant functional disorders and syndromes identification that need to be affected: ultrasound therapy – for metabolism within improvement; neuroelectrostimulation and non-selective phototherapy – for trophic and local bloodflow in tissues improvement; local air cryotherapy – for pain decrease reduction of swelling and pain syndrome; low-intensity laser therapy – for tissue metabolism increasing.

At the long-term stage of rehabilitation, in particular with the formation of scar contractures, natural healing resources of sanatoriums and resorts are widely used, in particular balneotherapy with mineral waters (hydrogen sulfide, radon, etc.), hydrotherapy and thalassotherapy (sea bathing), peloid treatment.

Let us give a specific clinical case.

A patient C. was admitted to the surgical department with a diagnosis – fire penetrating bullet wound of the right knee joint. The right leg tibial bone proximal metaepiphysis fiery intraarticular fracture. Right leg peroneal nerve posttraumatic neuropathy. Traumatic shock of the II-III degrees.

We have been fulfilled.

1. Primary surgical treatment of the wound (Fig. 1-A). Fixation of a tibial bone fracture using rod device for limbs external fixation (RDLEF) (Fig. 1-B).
2. Multimodal monitoring (dynamic digital thermography, right leg soft tissues sonography at the level of the injury and surrounding soft tissues). The study was conducted dynamically: before the operation once per day, after the operation – the 1st day 6 times a day, the 2nd day 4 times a day, the 3rd day 3 times a day (Fig. 1-C, 1-D).
3. Repeated surgical treatment of the wound defect and a controlled negative pressure system installation (Fig. 1-E, 1-F).
4. Repeated surgical treatment of the wound defect. The controlled negative pressure system dismantling. Wound defect reconstruction using a hybrid method (Key Stone + rotary flap) (Fig. 2-A).
5. The RDLEF dismantling 3 months after the injury (Fig. 2-B).
6. Physical exercise starting from the 4th month beginning (the first week after the RDLEF dismantling)

We provided constant monitoring according to the multimodal scheme after each session of therapeutic physical training and registered the temperature gradient increase after each session by 0.33±0.04°C (Fig. 2-C, 2-D).

According to the results of surgical and rehabilitation treatment the supporting function of the limb is restored by 75%. The length is restored by 100% that is characterized by (a) active bending 70 degrees; (b) passive bending 65 degrees; (c) active and passive extension restored to 180 degrees.

Sensibility in the lower leg and foot has been restored by 70% (Fig. 2-E, 2-F, 2-G).

DISCUSSION

We divide our obtained data into immediate clinical and delayed organizational ones, which, at the same time, with rapid implementation into the medical practice of providing support to the military forces of Ukraine, will contribute to the development of a significant clinical effect.

The first most important block of obtained data convincingly testifies to the full-fledged functional recovery of the patient's injured limbs as a result of applying our original step-by-step scheme of providing medical care in cases of STGD. To the full functional recovery, we will add the critical importance of such a result for the functioning of the entire organism as a whole, for the symmetrical functioning of the contralateral leg, as well as the speed of obtaining a positive clinical result.

Let us add that this happened as a result of our many years of clinical improvement of surgical treatment tactics, optimization of diagnostic processes, and currently developing tactics of rehabilitation stages of treatment [8-11].

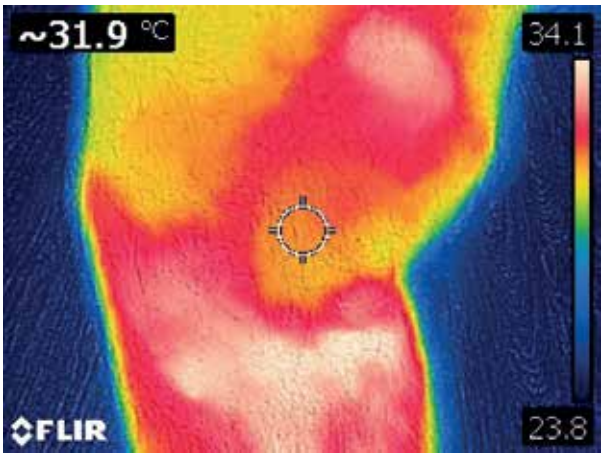
With regard to our proposals for the original staged scheme of medical care providing to victims with STGD, we allow ourselves to say the following.

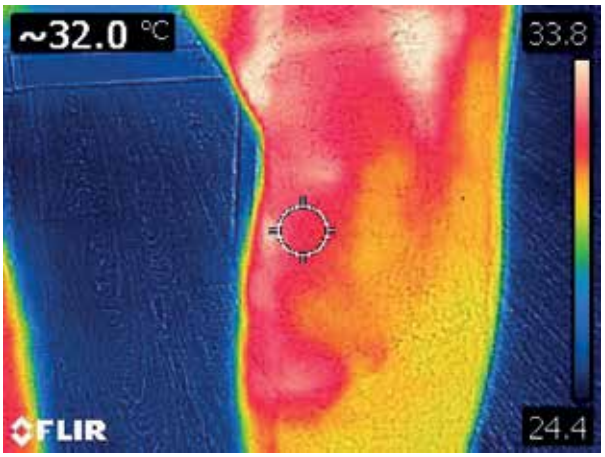
Rehabilitation measures are provided at the third and fourth level of medical care. They are provided according to the available material and technical base of the health care facility where the injured person is staying, etc. At the same time, the provision of medical rehabilitation services in sanatorium-resort facilities of the Armed Forces of Ukraine, in our opinion, can be attributed to the fourth level [5].

Rehabilitation measures in sanatorium-resort conditions in the post-acute and long-term rehabilitation periods

A – Primary surgical treatment of the wound;

B – Fixation of a tibial bone fracture using rod device for limbs external fixation;





C&D – dynamic digital thermography after the injury;

E&F – repeated surgical treatment of the wound and a controlled negative pressure system installation.

Fig. 1. Diagnostic and treatment measures in patient C

for wounded servicemen are implemented exclusively in sanatorium-resort facilities of the Armed Forces of Ukraine.

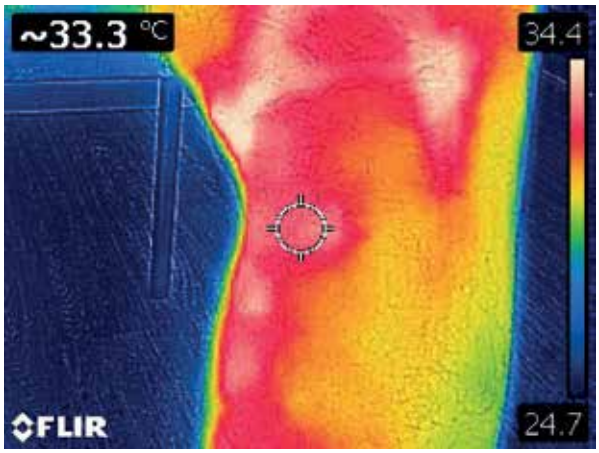
We suppose the transfer to a sanatorium for wounded persons is possible under the following conditions: (a) stable somatic condition; (b) self-service within the department; (c) satisfactory coagulogram indexes with hemoglobin level >100 g/l; (d) body temperature within normal limits; (e) removal of postoperative sutures, drains, satisfactory condition of the postoperative wound; (f) postoperative complications absence.

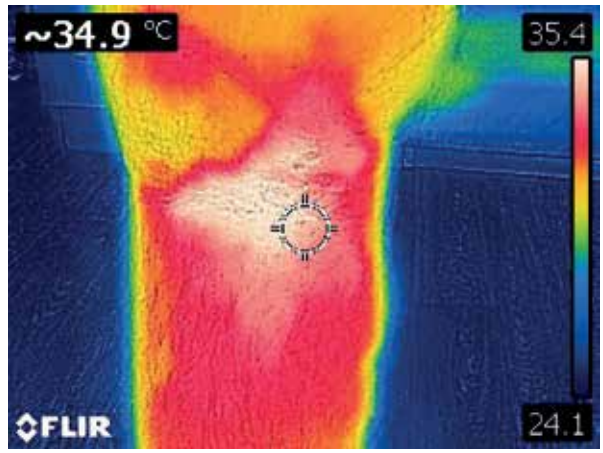
We propose to carry out the inpatient stage of rehabilitation in the acute and post-acute rehabilitation periods immediately after surgical treatment in a health care facility where specialized or highly specialized surgical care was provided. It lasts the entire time of the injured person's stay in the hospital from the first hours after surgical treatment [3].

Resuming, one should mentioned the following. Timely rehabilitative measures at all stages of providing medical care in the Armed Forces, including sanatoriums, contribute to the reduction of hospital bed days, longer stay of the wounded under professional medical supervision, in particular at the stage of formation of a "skin patch", the number of complications reduction, including infectious ones at the stages of reconstructive and restorative surgical treatment and the formation of contractures at the long-term stage of rehabilitation [8, 12].

A – Wounded leg after gun-shot defect reconstruction using a hybrid method;

B – Wounded leg 3 months after the injury; the rod device for limbs external fixation is dismantled;





C&D – dynamic digital thermography after the physiotherapy sessions;

E, F&G – injured leg after a complex of therapeutic and rehabilitation measures

Fig. 2. Medical and rehabilitation measures in patient C

The dividing of early sanatorium-resort rehabilitation stage for the wounded with severe STGD depending on the staged surgical treatment is scientifically justified.

We believe that our medical success is due to various step-by-step models of rehabilitation measures that were proposed for the wounded with different degrees of severity. A three-step model of rehabilitation was developed for wounded persons with minor injuries. We proposed a four-stage model of rehabilitation for the wounded with severe trauma and the same four-stage model of rehabilitation we proposed for the wounded with extremely serious injuries.

CONCLUSIONS

1. Timely rehabilitation measures at all stages of providing medical care in the Armed Forces are faster and more effective.
2. The organizational and methodological foundations of the staged rehabilitation system of wounded servicemen with STGD at different levels of medical care depending on the severity of the injury and the tactics of surgical treatment have been developed.
3. The early sanatorium-resort rehabilitation stage separation of patients with severe soft tissue injuries depending on the staged surgical treatment is scientifically justified. Groups of the wounded were allocated for rehabilitative treatment depending on their injury severity.
4. Different three- and four-staged models of rehabilitation measures for the injured with different severity are proposed.
5. A personalized approach to each wounded person is extremely important, taking into account his functional and clinical condition and based on the results of the rehabilitation examination.

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ORCID AND CONTRIBUTIONSHIP*
Igor A. Lurin: 0000-0001-6280-1725[A-F]
Igor P. Khomenko: 0000-0002-8199-5083[A,E,F]
Olena A. Gozhenko: 0000-0002-4071-1304[B-D]
Volodymyr V. Nehoduiko: 000-0003-4540-5207[C-F]
Oleg S. Herasimenko: 0000-0002-0039-5757[A,B]
Serhii V. Tertyshnyi: 0000-0002-4949-5409[D,E]
Evgen O. Grigoriev: 0009-0004-4577-2511[C-E]

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ADDRESS FOR CORRESPONDENCE
Serhii V. Tertyshnyi
Military Medical Clinical Center of the Southern Region
2 Pirogovska St., 65044 Odesa, Ukraine
e-mail: tertyshnyi.sergey@gmail.com

* Contribution: A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval.

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SATISFACTION WITH THE PHYSICAL THERAPY IN PATIENTS WITH ADHESIVE CAPSULITIS AND MYOFASCIAL PAIN SYNDROME

Andrii P. Rusanov[1,2], Volodymyr V. Vitomskyi[1], Iryna V. Roi[2], Nataliia O. Borzykh[2], Anton P. Kudrin[2], Maryna V. Vitomska[1]

[1]NATIONAL UNIVERSITY OF UKRAINE ON PHYSICAL EDUCATION AND SPORT, KYIV, UKRAINE

[2]GI "INSTITUTE OF TRAUMATOLOGY AND ORTHOPEDICS OF THE NATIONAL ACADEMY OF MEDICAL SCIENCES OF UKRAINE", KYIV, UKRAINE

ABSTRACT

Aim: To investigate and compare satisfaction with the physical therapy in patients with adhesive capsulitis of the shoulder joint and concomitant thoracic myofascial pain syndrome undergoing outpatient and home programs.

Materials and Methods: The study involved 76 participants. Shoulder joint mobility and pain in myofascial trigger points were assessed before and after the physical therapy program. Scale to measure patient satisfaction with physical therapy was used after the program. Patients of both groups received physical therapist consultations. The first group of patients received end-range mobilization (performed by a physical therapist) and performed ischemic compression (without any assistance). The second group of patients performed therapeutic exercises and ischemic compression without any assistance at home. The duration of the program in both groups comprised 3 weeks.

Results: Mobility and pain indicators were improved in both groups. However, the results of the second assessment were better in the first group. Physical therapy satisfaction scores were high in both groups, but the first group had statistically better results in four questionnaire items and in the total score. Me (25%; 75%) indicators of the total satisfaction score comprised 85 (84.75; 85) points in the first group and 78 (77.75; 79) points in the second group.

Conclusions: The patients who received consultations, end-range mobilization, and performed ischemic compression had a higher level of satisfaction as compared to the patients who attended consultations and performed therapeutic exercises and ischemic compression.

KEY WORDS: rehabilitation, mobilization, exercises, musculoskeletal system, trigger points

INTRODUCTION

Diseases and injuries of the musculoskeletal system reduce person's quality of life, work capacity, and limit their participation in everyday activities [1-4], which negatively affects social and economic indicators of the society development. These negative consequences are also relevant for adhesive capsulitis of the shoulder joint (ACSJ) [5]. This disease is often diagnosed as a result of the physical examination by a therapist and imaging methods [6]. However, it is also indicated that imaging methods are not required [7]. The key clinical manifestations of this disease are pain and limited mobility [8]. Besides, common results of physical examinations and patient complaints include deep and aching pain, presence of a pain arc, worsening pain at night, inability to sleep on the affected side, and wasting of shoulder muscles [6]. According to the scientific literature, ACSJ prevalence varies to some extent and ranges from 2% to 5% [9, 10]. According to the statistical data, this pathology is more often diagnosed among females [11], who, however, have a better effectiveness of the therapy, particularly, the dynamics of clinical symptoms [10]. Restriction of the active and passive amplitude in the shoulder joint is caused by mechanical reasons, such as thickening of the shoulder joint capsule, development of fibrosis and adhesions [9]. These clinical manifestations lead to the development of stiffness in the shoulder, limitations in activity and participation elements, diminished quality of life and work capacity. In the natural course of ACSJ, its symptoms may disappear without any interventions. However, there is also evidence of persistent and long-term functional limitations [10].

At the same time, ACSJ has concomitant myostatic contracture [12], which can form the basis for the development of myofascial pain syndrome (MPS), characterized by the presence of painful trigger points (TPs). Such points are defined as nodules or areas with painful irritability in the skeletal muscle detected by palpation. Stimulation of TPs leads to intensive referred pain, convulsive reactions, and neuroelectrical activity [13]. This syndrome is often not diagnosed in other diseases of the musculoskeletal system, but it is considered a common component of most persistent pain syndromes [14]. Besides, latent TPs are characteristic of various disorders of the locomotor apparatus [15].

Despite the existence of a relevant ground for a comprehensive study of the use of physical therapy (PT) methods among patients with ACSJ and concomitant MPS, this field still remains unexplored. PT is studied separately for ACSJ, particularly, regarding the use of end-range mobilization (ERM) and therapeutic exercises [16]. Studies on MPS are focused on the effectiveness of ischemic compression (IC), various manual techniques and massage, heat therapy, electrotherapy, shockwave therapy, ultrasound, and therapeutic exercises [17]. Satisfaction with the received PT in patients with ACSJ and concomitant MPS remains unexplored in this research area. At the same time, patient satisfaction is a considerable element of quality care.

AIM

The aim of the study is to investigate and compare satisfaction with the PT in patients with ACSJ and concomitant thoracic MPS undergoing outpatient and home programs.

MATERIALS AND METHODS

PARTICIPANTS

76 patients were involved in the study, which was conducted at the GI "Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine". The patients had their diagnostic tests carried out and received consultations of an orthopedist-traumatologist before the PT. Ethical consent was provided by the ethics committee of the local institution (protocol No. 2 dated March 30, 2023) and in accordance with the Helsinki declaration. The inclusion and exclusion criteria on the study corresponded to those presented in the previous studies [18, 19].

METHODS

The amplitude of shoulder joint movements was measured before and after the PT in accordance with the methodological guidelines [20]. To assess the amplitudes of rotations, the shoulder was retracted by 15°. A numerical scale (from 0 to 10) was used to assess pain when pressing on TPs (2.5 kg×cm-2, a VTSYIQI digital force gauge was used), with the highest score among the studied TPs being recorded. Scale to measure patient satisfaction with PT was used in the study [21]. The questionnaire consists of 17 questions with 5 answer options. You can get from 1 to 5 points in each question. The total score is the sum of the scores of all the questionnaire items. A higher score corresponds to a higher level of satisfaction with PT. The survey was conducted after the end of the three-week PT (the first survey).

INTERVENTION

The patients were divided into two groups: the first main group (G1, n=38) and the second main group (G2, n=38). All the patients were also consulted by a physical therapist.

G1 participants were consulted by a physical therapist on the specifics of ERM and IC, including pain levels, importance of interaction with a physical therapist, and measures to reduce pain during the procedures. G1 patients received ERM with the assistance of a physical therapist 5 times a week to improve shoulder joint mobility. Mobilization was used in the form of intensive ERM from I to V degrees of intensity according to Maitland classification system. A detailed description of the ERM procedure is available in previous studies [18]. The number of procedures could be changed by the physical therapist. Most patients received 15 procedures within 3 weeks. One patient received 13 procedures, two patients – 14, two patients – 16, and one patient – 17. In G1, the average duration of the PT program comprised 3 weeks.

G2 participants were consulted on the specifics of therapeutic exercises (pendulum and stretching) and IC. Patients received information letters with the description of the exercises and photos. The exercises were performed twice a day. Planned counseling of the patients of G2 by a physical therapist took place at the beginning of the 2nd and 3rd weeks of the PT, and the final one – at the end of the 3rd week. During the consultations, the physical therapist received information from the patients about their exercise practice and IC, provided additional explanations, and evaluated the dynamics. If necessary, the patients clarified information about their PT. A detailed description of therapeutic exercises is available in previous studies [19]. In G2, the duration of the PT program comprised 3 weeks.

Patients in both groups were advised to perform all the activities, including household ones, with the maximum possible amplitude of movement in the shoulder joint.

In terms of TPs therapy, the patients performed IC without any assistance: G1 - in the clinic and G2 - at home. During the first consultation, the physical therapist detected localization of TPs. The patient was instructed on the techniques and ways of influencing TPs. A detailed description of IC is available in previous studies [18]. It should be noted that IC of one TP lasted 30 seconds. Several compressions could take place on one TP. The pain had to be of average or above average level. IC was performed daily for 15-20 minutes.

STATISTICAL ANALYSIS

SPSS Statistics 21 was used in the study. There were no paired indicators for the comparison (between the groups or assessments) that corresponded to the law of normal distribution according to the Shapiro-Wilk test. Taking this into account, the median and quartiles (Me (25%; 75%)) were calculated. Additionally, the mean value (x) and standard deviation (SD) could be calculated as well. The Wilcoxon test was used to compare the results in one group. The Mann-Whitney test (Z) and the Pearson's chi-squared test (χ^2) were used to compare the results of the groups.

RESULTS

The groups did not have any statistically significant difference in terms of patient age and duration of symptoms. The mean age was 54.5 (50; 59) years in G1 and 54 (45; 60.5) years in G2 (Z=-0.411; p=0.681). The duration of symptoms comprised 5 (3.75, 7) months in G1 and 5.75 (3.5, 7) months in G2 (Z=-0.736; p=0.462). The proportion of males was smaller in both groups: 26.3% in G1 and 34.4% in G2. The groups had no statistical difference in the number of females and males (χ^2=0.561; p=0.454). Right-sided ACSJ was diagnosed in 44.7% of G1 patients and in 47.4% of G2 patients (χ^2=0.053; p=0.818). The groups did not differ in the distribution of patients in terms of the factor affecting

their dominant limb. The proportion of patients with an affected dominant arm was 42.1% and 47.4% (χ^2 = 0.213; p=0.645), respectively. The number of patients who received steroid injections after consultation with an orthopedist-traumatologist was slightly smaller in G1 and comprised 28.9%. G2 had 34.2% of such patients, but the groups did not differ in terms of this indicator (χ^2=0.244; p=0.622). A statistically equal number of patients in the groups received nonsteroidal anti-inflammatory drugs during the study: 5.3% G1 and 2.6% G2 (χ^2=0.347; p=0.556). Comparison of the first goniometry results did not reveal any statistical difference between the groups (Table I). Participants of both groups showed positive dynamics in the mobility of the shoulder joint (p<0.001). Comparison of the final goniometry results revealed statistical advantage of G1 (Table 1).

The results of the first assessment of pain in TPs did not differ between the groups (Z=-1.250; p=0.211). G1 patients demonstrated a significant difference between the initial and final results: 9 (9; 9) points versus 3.5 (3; 5) points (Z=-5.424; p<0.001). A statistical difference was also present when comparing the results of G2 patients: 9 (9; 9) points versus 4 (4; 4) points (Z=-5.596; p<0.001). Accordingly, positive dynamics were observed among the patients of both groups. Final pain scores in TPs were better in G1 (Z=-2.263; p=0.024).

Comparison of the group's results in the questionnaire items regarding patient satisfaction with the PT revealed statistical differences in four of them (Table 2).

Taking into account that the vast majority of the patients scored 5 and 4 points to the questionnaire items, it is reasonable to consider additionally the average values (Fig. 1).

The total score of the scale was different in patient groups (Z= -4.607; p<0.001). Me (25%; 75%) indicators comprised 85 (84.75, 85) points in G1 and 78 (77.75, 79) points in G2. x±SD indicators were 83.39±3.82 and 78.24±3.37 points, respectively.

DISCUSSION

The obtained results confirm positive dynamics of active and passive amplitudes of the shoulder joint movement and severity of pain in TPs among the patients of both groups. At the same time, the final results were better in G1. PT satisfaction scores were high, but G1 had statistically better results in four questionnaire items and total score. In particular, the advantages of G1 were revealed in the items related to the diagnosis made by a physical therapist, thoroughness in treatment and examination, working out the treatment

Table 1. Results of measuring the amplitude of movements during the first and final assessments, degrees

Movement		First assessment		p*	Final assessment		p*
		G1 (n=38)	G2 (n=38)		G1 (n=38)	G2 (n=38)	
Abduction	passive	56 (40; 64.3)	54 (46.8; 60)	0.486	126 (123.8; 126)	89.5 (85.8; 101.3)	<0.001
	active	53.5 (32; 61.3)	50 (42.8; 55.5)	0.433	125 (122.3; 126)	86 (83; 97)	<0.001
Flexion	passive	67.5 (55.8; 92)	67 (53.8; 72)	0.644	180 (180; 180)	130.5 (96; 137.3)	<0.001
	active	62.5 (51; 87)	63.5 (49; 69.3)	0.763	179 (179; 180)	120 (94; 126.3)	<0.001
Internal rotation	passive	16.5 (14; 21)	16 (14; 19)	0.609	90 (90; 90)	48 (46; 50)	<0.001
	active	12.5 (11; 19)	12 (10.75; 14)	0.598	90 (89; 90)	44 (42; 45)	<0.001
External rotation	passive	18 (16; 21)	18 (16; 20)	0.746	90 (90; 90)	48.5 (46.75; 50)	<0.001
	active	15 (12.8; 18)	14 (12; 17)	0.348	90 (89; 90)	45 (43; 46)	<0.001

*Note. * – Mann-Whitney test.*

Table 2. Results of determining items of the Scale to measure patient satisfaction with physical therapy, points

	Items	Groups		Criterion*	p
		G1 (n=38)	G2 (n=38)		
1	Physiotherapists were good about explaining the reason for my physiotherapy	5 (5; 5)	5 (5; 5)	-0.625	0.532
2	I think the physiotherapist had materials and equipment needed to complete my care	5 (5; 5)	5 (5; 5)	-1.619	0.105
3	Physiotherapists always made me feel their diagnosis was correct	5 (5; 5)	4 (4; 5)	-3.478	0.001
4	The physiotherapists were thorough in treating and examining me	5 (5; 5)	4 (4; 4.25)	-6.173	<0.001
5	I had easy access to the physiotherapists I needed regarding feedback on my physiotherapy procedures	5 (5; 5)	5 (5; 5)	-0.674	0.500
6	I didn't have to wait for a long period before being attended to by the physiotherapists after I was referred to them	5 (5; 5)	5 (4; 5)	-1.600	0.110
7	My physiotherapists treated me in a very friendly and courteous manner	5 (5; 5)	5 (4; 5)	-1.035	0.301
8	Those who provided my physiotherapy care always took their time when they treated me	5 (5; 5)	4 (4; 5)	-2.111	0.035
9	The physiotherapists always acknowledged what I told them	5 (5; 5)	5 (4; 5)	-2.895	0.004
10	I had no doubts about the ability of the physiotherapists who treated me	5 (5; 5)	5 (4.75; 5)	-0.820	0.412
11	I felt confident that I was receiving the physiotherapy I need without being setback financially	5 (5; 5)	5 (4; 5)	-1.698	0.090
12	I was very satisfied with the physiotherapy care I received	5 (5; 5)	5 (4; 5)	-2.118	0.034
13	The physiotherapists who treated me gave me respect	5 (5; 5)	5 (4; 5)	-1.250	0.211
14	During my physiotherapy I was allowed to say everything that I thought was important	5 (5; 5)	5 (4; 5)	-4.020	0.000
15	The physiotherapists who treated me had a genuine interest in me as a person	5 (5; 5)	5 (4; 5)	-4.406	0.000
16	I was fully compliant with the physiotherapy treatment I received	5 (5; 5)	5 (4; 5)	-2.232	0.026
17	Due to my level of satisfaction my compliance to the physiotherapy came naturally	5 (5; 5)	5 (4; 5)	-1.316	0.188

*Note. * – Mann-Whitney test.*

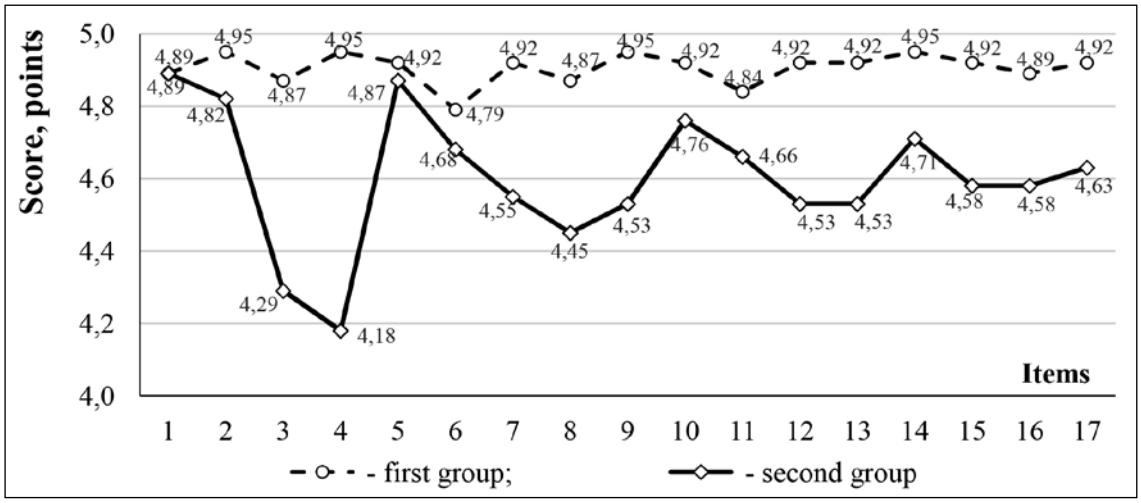

Fig. 1. The average values of the results in the items of the Scale to measure patient satisfaction with physical therapy among the patients

time and listening to the patient. Hypothetically, it can be assumed that G1 patients had better results due to better communication with the physical therapist during ERM and the necessity of maximum mutual understanding, aligned goals, patient awareness, since mobilization used was rather intensive. At the same time, the high level of satisfaction in G2 can be explained by the sufficient number and quality of the consultations provided by the physical therapist.

The previous studies assessed satisfaction with PT in patients of the orthopedic [27] and cardiosurgical profile [21], investigated the relationship between satisfaction and as other factors [22]. There are also very few studies on satisfaction with therapy in ACSJ or MPS. In particular, a meta-analysis of the effectiveness of exercises in ACSJ [23] indicated that no study used patient satisfaction to assess the results. One of the studies revealed that patients with ACSJ who received PT with the Mulligan's mobilization technique had better satisfaction, pain, and mobility indicators as compared to the group performing passive stretching exercises [24]. One of the systematic reviews indicated that patient satisfaction with ACSJ is improved by conservative treatment [25]. At the same time, according to another systematic review, manipulation under anesthesia has no advantages over non-surgical treatment of AC in terms of patient satisfaction [26].

The obtained results are also consistent with the conclusions of and other studies [27], namely concerning the high level of patient satisfaction with PT of the musculoskeletal system. High level of satisfaction with PT is also mentioned in a study involving cardiosurgical patients [21]. According to the study by P. Beattie [28], patients who received the entire course of PT from only one specialist had a higher level of satisfaction. This circumstance can also explain high results obtained in G1 and G2.

At the same time, there are also studies that report a moderately high level of satisfaction with PT among patients with musculoskeletal diseases. According to the researchers, patients consider specialists who do not spend enough time with them less popular [29].

The obtained results are consistent with the previous research in the fact that patients have high levels of satisfaction, and also present new data on the level of satisfaction with PT among patients with ACSJ and MPS.

CONCLUSIONS

The patients who received consultations, ERM procedures with a physical therapist, and performed IC without any assistance had a higher level of satisfaction as compared to the patients who attended consultations with a physical therapist and performed therapeutic exercises and IC without any assistance.

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ORCID AND CONTRIBUTIONSHIP*
Andrii P. Rusanov: 0000-0002-4357-7059[A-F]
Volodymyr V. Vitomskyi: 0000-0002-4582-6004[D]
Iryna V. Roi: 0000-0002-4138-4691[E]
Nataliia O. Borzykh: 0000-0002-3733-7905[F]
Anton P. Kudrin: 0000-0002-8156-2755[F]
Maryna V. Vitomska: 0000-0002-5163-3954[F]

ADDRESS FOR CORRESPONDENCE
Volodymyr V. Vitomskyi
National University of on Physical Education and Sport, Physical Therapy and Occupational Therapy Department,
1 Fizkultury St., 03150 Kyiv, Ukraine
e-mail: vitomskiyvova@gmail.com

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REHABILITATION FEATURES FOR PATIENTS WITH DIAPHYSEAL HUMERUS FRACTURES DURING CONSERVATIVE TREATMENT

Serhii V. Kononenko, Oleksandr V. Pelypenko, Oleksandr S. Kovalov, Yevheniy E. Chip

POLTAVA STATE MEDICAL UNIVERSITY, POLTAVA, UKRAINE

ABSTRACT

Aim: Determination of the key criteria for selecting the optimal physical rehabilitation scheme depending on the chosen method of conservative treatment.

Materials and Methods: The study involved 53 patients with diaphyseal humerus fractures. In all cases, conservative functional treatment methods have been applied.

Results: Based on the applied methods of conservative treatment, four clinical groups for medical rehabilitation have been identified: A, B, C, D, each containing 2 subgroups, depending on the relationship between the bone fragments and the sites of muscle attachment in the diaphyseal segment of the humerus. Subgroup "1" involved patients with diaphyseal humerus fractures, where the fragments serve as the sites of attachment for muscles. Subgroups "2" encompassed cases with fractures in the specified area, where the fragments do not serve as the sites of muscle insertion. The assessment of the functional activity of the elbow and shoulder joints was performed using the MEPS and CMS scales, respectively.

Conclusions: The anatomical and topographical features of the muscle component are crucial for selecting the optimal tactics for conducting rehabilitation measures.

KEY WORDS: fractures, rehabilitation, treatment, joints, functional treatment

INTRODUCTION

According to a series of scientific studies, diaphyseal humerus fractures account for 1-5% of the total number of skeletal bone fractures in humans. Among them, closed fractures predominate [1, 2].

The abovementioned fractures can be caused by both high-energy and low-energy traumas. Among elderly and senile patients, the leading cause of humerus fractures is the impact of a low-energy traumatic factor [3-5].

The main approaches in treating of diaphyseal humerus fractures are operative and conservative methods. The application of conservative functional treatment through functional bracing remains a foundational choice for treating isolated fractures, yielding generally favorable outcomes and it is often used in patients with comorbid conditions [6-9].

The treatment of diaphyseal humerus fractures involves not only restoring anatomical characteristics but also achieving a favorable functional outcome, determined by the indicators of elbow and shoulder joint mobility and the patient's ability to resume normal daily activities [10, 11].

The effective conservative treatment can be ensured by taking into account and having a deep understanding of the anatomical characteristics of the specified area and the biomechanical features of bone fragment displacement in various types of fractures across different gender and age categories of patients [12, 13].

Early functional loading of the shoulder and elbow joints can be successful only if the type and characteristics of the fixation devices used during conservative treatment are taken into account [14, 15].

AIM

Determining the key criteria for selecting the optimal physical rehabilitation scheme depending on the chosen method of conservative treatment.

MATERIALS AND METHODS

The study involved 53 patients ranging in age from 24 to 90 years. In terms of gender distribution, females constituted 68% (36), while males were 32% (17). According to the WHO age classification, young individuals comprised 15% (8), middle-aged individuals accounted for 15% (8), elderly individuals comprised 57% (30) and the senile individuals accounted for 13% (7) of the total. The average age of female patients was 63.2 years, while that of male patients was 56.1 years.

The time of initial patient presentation ranged from 30 minutes to 48 hours from the moment of injury. In 40% (21) of cases, hospitalization occurred within 30 minutes to 2 hours, in 34% (18) it was within 2 to 6 hours, and in 17% (9) within 7 to 24 hours. Hospitalization within the second day following the traumatic event took place in 9% (5) of cases.

The predominant cause of fractures was the impact of a low-energy traumatic force, specifically falls from one's own height onto an extended limb or onto the side, observed in 64% (34) of cases. Injuries resulting from high-energy traumatic agents were identified in 36% (19) of individuals.

In 100% of patients, closed fractures of the diaphyseal segment of the humerus without damage to the skin have been diagnosed. An adduction type of displacement has been found in 45% (24) of cases, while an abduction type of bone fragment displacement has been identified in 55% (29) of cases. According to the AO classification, the distribution was as follows: simple fractures of type 12 A were found in 56,6% (30), fractures with a loose bone fragment of type 12 B in 24,5% (13) and complex multifragmentary fractures of type 12 C in 18,9% (10) of cases.

A detailed description of fractures according to the AO classification is shown in Table 1.

Conservative treatment methods were applied in 100% of patients. Traditional humerus cast was used in 26% (14) of cases, splint-cloth orthosis in 26% (14), Sarmiento brace in 23% (12) and modified three-point orthosis in 25% (13) of cases.

At the initial patient presentation stage and throughout the treatment period, in order to choose the optimal closed reduction technique, further tactics and scheme for rehabilitation recovery, all patients underwent X-ray examinations of the injured segment in standard plane projections. In 26% (14) of cases, computed tomography of the diaphyseal segment of the humerus and anatomically accurate three-dimensional modeling techniques were used during the initial patient presentation.

During closed reduction of fractures with the abduction type of displacement, the "Reclinator Chair for Closed Fracture Reduction" (Ukrainian Utility Model Patent No. 14726 as of May 12, 2021) was utilized. This chair enabled achieving a passive and non-traumatic anatomical restoration of the axis of the injured segment.

The assessment of the nature and the vector of bone fragment displacement was carried out using the muscle-tendon scheme of typical contact relationships. A comparative analysis of the interposition, degree of bone fragment displacement and the quality of their reduction was performed before and after the application of conservative treatment methods in a dynamic manner.

The nature of the fracture, presence of bone fragments and their relationship with the attachment sites of the pectoralis major, teres major, deltoid muscles and the latissimus dorsi muscle, as well as the chosen method of conservative treatment, had a significant impact on determining the approach for the follow-up physical rehabilitation and the grouping of patients.

According to the conclusions of the Ethics Commission of the PSMU, the paper meets the requirements of the Helsinki Commission. Patients, assigned in the clinical groups, participated with informed consent.

RESULTS

Depending on the applied methods of conservative treatment, four clinical groups for medical rehabilitation have been identified: A, B, C, D, each consisting of 2 subgroups, based on the relationship between the bone fragments and the sites of muscle attachment in the diaphyseal segment of the humerus. Subgroup "1" involved patients with diaphyseal humerus fractures, where the fragments serve as the sites of attachment for muscles. Subgroups "2" encompassed cases with fractures in the specified area, where the fragments do not serve as the sites of muscle insertion.

The distribution of clinical groups for medical rehabilitation based on the applied method of conservative treatment and their relationship with muscle insertion sites is provided in Table 2.

Group A involved 14 patients (26.4%) with fractures of the humeral diaphysis, treated using a standard humerus cast. Among them, simple two-part fractures of type 12 A predominated, accounting for 57.1% (8). Fractures with loose bone fragment of type 12 B, and complex multifragmentary fractures of type 12 C were identified in an equal number of cases, specifically 21.45% (3) each.

Subgroup A1 consisted of 6 patients (11.3%) with comminuted fractures of the humeral diaphysis. Fractures of type 12 B and 12 C were equally represented. Considering the relationship between bone fragments and the sites of attachment for the key muscles in the diaphyseal segment, as well as the specific

Table 1. The description of diaphyseal humerus fractures according to the AO classification

No.	The type of AO Fracture Classification	Number of fractures, n	Number of fractures, %
1.	Simple spiral 12-A1	6	11,3
2.	Simple oblique12-A2	9	17,0
3.	Simple transverse 12-A3	15	28,3
4.	Spiral wedge 12-B1	4	7,5
5.	Bending wedge 12-B2	6	11,3
6.	Fragmented wedge 12-B3	3	5,7
7.	Complex spiral 12-C1	5	9,4
8.	Complex segmental 12-C2	2	3,8
9.	Complex irregular 12-C3	3	5,7
	Total	53	100

Table 2. Distribution of clinical groups for medical rehabilitation of patients with diaphyseal humerus fractures based on the applied method of conservative treatment and their relationship with the sites of muscle attachment

Group No.	Subgroup name	Method of conservative treatment	Relationship of bone fragments with muscle insertion sites	Number of individuals, n (%)
1.	A1	cast	yes	6 (11,3 %)
2.	A2	cast	no	8 (15,1 %)
3.	B1	splint-cloth orthosis	yes	8 (15,1 %)
4.	B2	splint-cloth orthosis	no	6 (11,3 %)
5.	C1	Sarmiento brace	yes	6 (11,3 %)
6.	C2	Sarmiento brace	no	6 (11,3 %)
7.	D1	modified three-point orthosis	yes	7 (13,3 %)
8.	D2	modified three-point orthosis	no	6 (11,3 %)

Table 3. Description of the medical rehabilitation groups based on the type of joint mobility activity of the injured limb

Subgroup name / Mobility activity	A1	A2	B1	B2	C1	C2	D1	D2
Active flexion and extension movements of the fingers	+	+	+	+	+	+	+	+
Active flexion and extension movements of the wrist	+	+	+	+	+	+	+	+
Passive rotational movements of the forearm	-	+	+	+	+	+	+	+
Active rotational movements of the forearm	-	-	+	+	+	+	+	+
Passive flexion and extension movements of the forearm.	-	-	-	+	+	+	+	+
Active flexion and extension movements of the forearm	-	-	-	-	+	+	+	+
Passive adduction and abduction movements of the shoulder	-	-	-	-	-	+	+	+
Passive flexion and extension movements of the shoulder	-	-	-	-	-	+	+	+
Active flexion and extension movements of the shoulder	-	-	-	-	-	-	+	+
Active adduction and abduction movements of the shoulder	-	-	-	-	-	-	+	+

use of the standard humerus cast, patients in this subgroup performed active movements of fingers and wrist in the wrist joint. Movements of the forearm were excluded due to the increased risk of secondary displacement.

Subgroup A2 consisted of 8 patients (15.1%) with simple two-part fractures of type 12 A of the studied segment. The opposing parts of the humerus did not serve as the sites for the insertion of key muscles. Passive supination-pronation movements of the forearm of the injured limb, ranging from 110° to 150° for supination and 95° to 135° for pronation, were added to the complex of exercises of subgroup A1.

Group B included 14 patients (26.4%) whose treatment was carried out using a splint- cloth orthosis. According to the AO classification, simple two-part fractures predominated, accounting for 57.1% (8). Complex fractures of type 12 B and 12 C were encountered in 28.6% (4) and 14.3% (2) of cases, respectively.

Subgroup B1 involved 8 patients (15.1%) with a predominant occurrence of simple fractures of type 12 A, making up 50% (4). Fractures of type 12 B and 12 C were diagnosed in 25% (2), respectively. Rehabilitation measures among patients in this subgroup involved performing exercises of Group A, with the addition of active supination movements of the forearm within the range of 110°–150° and active pronation movements of the forearm within the range of 95°–135°.

Subgroup B2 consisted of 6 individuals (11.3%). Simple two-part fractures were identified in 66.7% (4) cases, and fractures with loose bone fragment of type 12 B were present in 33.3% (2). The subjects of the subgroup performed passive flexion and extension movements of the forearm in the elbow joint in combination with the exercise complex of subgroup B1.

Group C included 12 patients (22.6%) who were treated using the Sarmiento brace. Simple fractures of type 12 A according to the AO classification were diagnosed in 58.3% (7) cases; fractures of type 12 B and 12 C were present in 16.7% (2) and 25% (3) of cases, respectively.

Subgroups C1 and C2 each involved 6 patients (11.3%). Among patients in subgroup C1, whose bone fragments in the diaphyseal segment of the humerus served as the sites of insertion for key muscles, fractures of types 12 A, 12 B and 12 C were diagnosed in equal numbers, with 2 cases each (33.3%). In all cases, the exercise complex of subgroup B2 was supplemented with active flexion and extension movements of the forearm within the range of 30°–80° and 150°–180°, respectively.

In patients of subgroup C2, simple fractures predominated, accounting for 83.3% (5), while a complex multifragmentary fracture of type 12 C was present in 16.7% (1). The rehabilitation measures for this subgroup included the C1exercise complex with additional passive flexion-extension movements of the shoulder and passive abduction and adduction within the range of 15°–25°.

Group D consisted of 13 patients (24.6%) who were treated using a modified three-point orthosis. Simple two-part fractures were found in 53.8% (7) cases. Fractures of type 12 B and 12 C according to the AO classification were identified in 30.8% (4) and 15.4% (2) of cases, respectively.

Subgroup D1 included 13.3% (7) of patients with fractures in the specified segment. Among them, two-part fractures were predominant, accounting for 42.8% (3). The number of fractures with loose bone fragment and multifragmentary fractures was equal, both constituting 28.6% (2) each. Additionally, 11.3% (6) of cases were included in subgroup D2. Simple fractures of type 12 A were diagnosed in 66.7% (4) and fractures of type 12 B were present in 33.3% (2) of patients.

The fixation features of the modified compression orthosis allowed patients in Group D to perform a range of exercises from Groups A, B and C, supplemented with active movements in the shoulder joint. Specifically, they could perform flexion and extension of the shoulder within the range of 110°–120° and 15°–20°, respectively. Additionally, rehabilitation measures included active abduction and adduction movements of the shoulder within the range of 15°–30°.

The distribution of the study groups based on passive or active range of motion of the shoulder, elbow and wrist joints is shown in Table 3.

DISCUSSION

Rehabilitation measures among patients of all clinical groups were initiated immediately after immobilization and reduction of pain syndrome. The use of early rehabilitation measures, which includes active and passive movements of the shoulder and elbow joints, allows to achieve an increase in the range of motion of the joints [16-19]. The exercise routine was performed under the supervision of medical staff and independently by the patient after appropriate training.

Assessment of joint mobility was conducted after fracture consolidation and removal of immobilization devices. Evaluation of functional activity of the shoulder joint was carried out using the Constant-Murley Shoulder Outcome Score, while the elbow joint was assessed using the Mayo Elbow Performance Score. The use of the described scales allows form the most reliable assessment of motor activity of adjacent shoulder joints and is most often used in practice [20, 21].

Among the patients in clinical group A, who were treated using a standard humerus cast, the functional activity of the elbow joint assessed by MEPS ranged from 55 to 65 points, and on average, it was rated as satisfactory. The shoulder joint range of motion according to the CMS scale ranged from 43 to 57 points, with an average assessment of unsatisfactory. The limitations in adjacent joint movements of the injured limb are associated with the characteristics of the plaster cast, which do not allow for the specified movements and proper fixation of bone fragments.

The range of motion of the elbow joint among patients in group B, who were treated using a splint-cloth orthosis, according to the MEPS scale, ranged from 71 to 81 points, with an average assessment of good. According to the CMS scale, the range of motion in the shoulder joint ranged from 57 to 71 points and was evaluated as satisfactory.

The range of motion scores for the elbow joint according to the MEPS scale among the clinical group C patients, who were treated using the Sarmiento brace, ranged from 79 to 90 points. On average, these scores indicate a good functional result. The range of motion in the shoulder joint according to the CMS scale ranged from 75 to 91 points, with an average assessment of good to excellent.

Among the patients in clinical group D, who were treated using a modified compression three-point orthosis, the range of motion of the elbow joint according to the MEPS scale was evaluated as good, ranging from 81 to 89 points. The range of motion in the shoulder joint according to the CMS scale ranged from 87 to 93 points, indicating an excellent functional result.

The indicators of motor activity were not lower as in similar studies of functional treatment of diaphyseal fractures of the humerus, it shows the feasibility of using the proposed scheme of motor activity of the elbow and shoulder joints [9, 22].

CONCLUSIONS

The differentiated approach to selecting an optimal medical rehabilitation scheme, which is based on considering the type of fracture according to the AO classification, the relationship of bone fragments with the sites of insertion for key muscles and the fixation features of the applied conservative treatment method ensures achieving a combination of optimal range of motion in the elbow and shoulder joints, as well as preventing the occurrence of iatrogenic complications.

Taking into account the anatomical peculiarities and the relationship of existing bone fragments with the sites of attachment for the pectoralis major, teres major, deltoid muscles and the latissimus dorsi muscle allows for a clear determination of the optimal range of motion limits in adjacent joints. This approach reduces the risk of secondary displacement and enhances the quality of the patient's daily life.

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ORCID AND CONTRIBUTIONSHIP*

Serhii V. Kononenko: 0000-0002-9423-5104[A-F]
Oleksandr V. Pelypenko: 0000-0002-9010-3163[A,C-F]
Oleksandr S. Kovalov: 0000-0002-0661-2214[C-E]
Yevheniy E. Chip: 0000-0002-7397-0580[B,C,E]

ADDRESS FOR CORRESPONDENCE

Serhii V. Kononenko
Poltava State Medical University
23 Shevchenko St., 36024 Poltava, Ukraine
e-mail: doctorviolinist@gmail.com

CONFLICT OF INTEREST

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MORPHOLOGICAL AND FUNCTIONAL DEVELOPMENT OF ADOLESCENTS WITH HEALTH DISORDERS

Iryna I. Shaposhnikova[1], Svitlana M. Korsun[1], Tetiana A. Malechko[2], Roman M. Stasiuk[3], Volodymyr M. Serhiienko[3], Tetiana K. Bondar[4], Viktor H. Riabchenko[5]

[1]KHARKIV STATE ACADEMY OF PHYSICAL CULTURE, KHARKIV, UKRAINE
[2]INSTITUTE OF MODERNIZATION OF THE CONTENT OF EDUCATION, KYIV, UKRAINE
[3]SUMY STATE UNIVERSITY, SUMY, UKRAINE
[4]UKRAINIAN STATE DRAGOMANOV UNIVERSITY, KYIV, UKRAINE
[5]ACADEMY OF THE STATE PENITENTIARY SERVICE OF CHERNIHIV, CHERNIHIV, UKRAINE

ABSTRACT

Aim: To investigate the level of morphological and functional development as well as physical health of 9th-11th grade high schoolers ranking among a special medical group.

Materials and Methods: The research involved 328 high schoolers. Among them, 163 high schoolers (78 boys and 85 girls), who had health deviations and ranked among a special medical group and 165 high schoolers (80 boys and 85 girls), who ranked among a main medical group. Research methods: analysis and generalization of literary sources, medical and biological methods, methods of mathematical statistics.

Results: It was found that indicators of morphological and functional development of adolescents from the special medical group (both males and females) were significantly worse ($p<0.05$-0.001) than indicators of adolescents from the main medical group. Most indicators of the special medical group adolescents are at low and below-average levels. The dynamics of indicators in the special medical group adolescents, unlike the main medical group adolescents, tend to deteriorate in the process of schooling.

Conclusions: The results of the conducted research should be taken into account when organizing physical education training sessions with high schoolers ranking among a special medical group to accelerate their recovery from diseases, increase their motor activity, promote their health, and improve their level of life-sustaining activities.

KEY WORDS: morphological and functional development, health, adolescents, special medical group, motor activity

INTRODUCTION

The health of the younger generation is an integral indicator of society's overall well-being and one of the highest national values [1]. Modern health researchers [2] emphasize the steady increase in the level of overall morbidity, and the growing prevalence of abnormalities in the functioning of individual organs and body systems of high schoolers. In Ukrainian schools, there is a dynamic of annual increase in the number of high schoolers ranking among a special medical group for physical education, and their number in different regions of the country reaches 30-50% [3, 4]. Among the diseases of schoolchildren, the main place is occupied by posture and musculoskeletal disorders (over 30%), visual impairment (over 20%), digestive diseases (over 15%), functional disorders of the cardiovascular system (over 10%), endocrine system (over 10%), respiratory system (over 10%), and others [5, 6].

The system of physical education in secondary educational institutions should be a reliable basis for a high level of mental performance and intellectual development of high schoolers in the learning process, involving them in systematic physical exercises, forming the need for physical development and improvement to ensure a high level of health and professional longevity. Scientists argue that there is a close relationship between high schoolers' and students' health indicators and the organization of physical education in educational institutions [7, 8], however, insufficient number of physical education training sessions and their low status among children and parents reduce their potential value for promoting health, increasing physical fitness and forming motor experience of high schoolers. In addition, the organization of learning activities for high schoolers ranking among special medical groups during physical education training sessions in modern schools is ineffective. At best, high schoolers with disabilities exercise with mainstream high schoolers whenever possible, and at worst, they passively attend physical education training sessions or have medical certificates of exemption [9, 10]. The above has a negative impact on the indicators of morphological and functional development as well as physical health of high schoolers with disabilities.

AIM

The aim is to investigate the level of morphological and functional development as well as physical health of 9th-11th grade high schoolers ranking among a special medical group.

MATERIALS AND METHODS

The research was conducted during 2022-2023 at the Department of Biological Disciplines of Kharkiv State Academy of Physical Culture (Kharkiv, Ukraine). The research involved 163 adolescents (78 boys and 85 girls) who studied in the 9th (32 boys and 35 girls), 10th (24 boys and 27 girls), 11th (22 boys and 23 girls) grades of three schools (No 11, 28, 37) of Kharkiv (Ukraine) and had health deviations and ranked among a special medical group (SMG). We involved 165 high schoolers (80 boys and 85 girls) from the 9th (32 boys and 35 girls), 10th (25 boys and 26 girls), and 11th (23 boys and 24 girls) grades, who ranked among a main medical group (MMG) from the same schools to compare the morphological and functional development indicators of adolescents in the SMG with similar indicators of adolescents who do not have health problems. There was no special selection for the SMG and MMG. The SMG included all high schoolers of these grades and schools, and the MMG randomly selected high schoolers in the same number as the SMG. Adolescents in the SMG had the following health conditions, which we found out from their medical records: musculoskeletal diseases (flat feet, posture disorders) – 38.1%, diseases of the eyes – 26.4%, gastrointestinal tract (gastritis, cholecystitis, etc.) – 14.1%, respiratory system diseases (bronchitis, sinusitis, bronchial asthma) – 10.4%, nervous system diseases (neuroses, vegetative-vascular dystonia) – 4.9%, cardiovascular system (arrhythmia, congenital heart disease) – 3.7%, endocrine system diseases – 2.4%. However, these diseases were not a criterion for differentiating adolescents in our research. We studied the average indicators of morphological and functional development as well as health of adolescents (boys and girls) ranking among the SMG and compared them with the indicators of the MMG adolescents, as well as with age norms.

Research methods: analysis and generalization of literary sources, medical and biological methods, methods of mathematical statistics. The method of analysis and generalization contributed to the study of the literature on the topic of the research (20 sources from the scientometric databases PubMed, Scopus, Web of Sciences Core Collections, Index Copernicus and others were investigated).

Medical and biological methods were used to study indicators of morphological and functional development and physical health of adolescents. We have determined the following indicators: body mass index (BMI, the ratio of body weight to height), vital index (VI, the ratio of vital capacity of the lungs to body weight), strength index (SI, the ratio of hand strength to body weight) and Robinson index (RI, the ratio of the product of pulse and systolic blood pressure to 100) and Martine-Kushelevsky test (MKT) – heart rate recovery time after a standard exercise (20 squats in 30 sec). The level of physical health (LPH) of adolescents was assessed according to the express method by H. L. Apanasenko, which is based on anthropometric indicators (body length, body weight, vital lung capacity, hand dynamometry) and the functional state of the cardiorespiratory system (heart rate, arterial blood pressure, duration of recovery processes) (Table 1) [11].

The methods of mathematical statistics were applied to correctly process the data and identify the difference between the indicators under study. The compliance of the data distribution with the Gauss' law was assessed using the Shapiro-Wilk W-test. The significance of the

Table 1. The evaluation of indicators of morphological and functional development as well as physical health of adolescents

Indicators	Gender	The levels of indicators of morphological and functional development as well as physical health of adolescents				
		Low	Below average	Average	Above average	High
BMI, kg/m²	boys	≤18,9	19,0-20,0	20,1-25,0	25,1-28,0	>28,0
	girls	≤16,9	17,0-18,6	18,7-23,8	23,9-26,0	>26,0
Points		-2	-1	0	-1	-2
VI, ml/kg	boys	≤50	51-55	56-60	61-65	>65
	girls	≤40	41-45	46-50	51-56	>56
Points		-1	0	1	2	3
SI, %	boys	≤45	46-50	51-60	61-65	>65
	girls	≤40	41-50	51-55	56-60	60
Points		-1	0	1	2	3
RI, c.u.	boys	>96	86-95	76-85	71-75	≤70
	girls	>96	86-95	76-85	71-75	≤70
Points		-1	0	1	3	5
MKT, s	boys	180 і >	120-180	90-120	60-90	59 і <
	girls	180 і >	120-180	90-120	60-90	59 і <
Points		-2	1	3	5	7
LPH, points	boys	≤2	3-5	6-10	11-12	>12
	girls	≤2	3-5	6-10	11-12	>12

difference in the results of the adolescents was determined during the studying based on the Student's t-test. The significance for all statistical tests was set at $p<0.05$. All statistical analyses were performed with the SPSS software, version 21, adapted to medical and biological researches. This research followed the regulations of the World Medical Association Declaration of Helsinki and ethical principles for medical research involving human subjects and was approved by the Academic Council of Kharkiv State Academy of Physical Culture (Protocol No. 12 dated 22.08.2022). Informed consent was received from all adolescents who took part in this research.

RESULTS

The results of the study of morphological and functional development as well as physical health of the 9th-11th grade high schoolers ranking among the SMG compared to high schoolers ranking among the MMG are presented in Table 2 (boys) and Table 3 (girls).

The analysis of body mass index, which characterizes the ratio of body weight and height in adolescents, shows that the indicators of boys ranking among the SMG are worse than in their MMG peers by 0.85 kg/m^2 in the 9th grade ($p>0.05$), by 0.98 kg/m^2 in the 10th grade ($p>0.05$) and by 1.32 kg/m^2 in the 11th grade ($p>0.05$). The SMG girls also had significantly lower indicators in terms of their body mass index than the MMG girls by 1.60 kg/m^2 in the 9th grade ($p<0.001$), by 2.08 kg/m^2 in the 10th grade ($p<0.001$), and by 1.85 kg/m^2 in the 11th grade ($p<0.001$). Although the body mass index of boys and girls of both study groups during their years of study is within the age norm of their physical development, the worse indicators in the SMG high schoolers is explained by higher body mass indexes caused by insufficient motor activity of adolescents with health problems. It was also found that 19 boys (24.3%) and 28 girls (32.9%), respectively of the SMG are overweight; among them, 13 boys (68.4%) and 17 girls (60.7%) were found to be overweight; 6 boys (31.6%) and 11 girls (39.3%) were found to be obese. Underweight was found in 7 adolescent boys (8.9%) and 11 girls (12.9%).

Both boys and girls from the SMG have significantly worse indicators in terms of their vital index than their MMG peers. The difference between the indicators of the SMG and MMG high schoolers in the 9th grade is 2.84 ml/kg

Table 2. Comparative analysis of indicators of morphological and functional development as well as physical health of boys of the 9th-11th grades of the special (n = 78) and main (n = 80) medical groups, Mean±SD

Year of study (grade)	n	SMG	n	MMG	Significance of the differences	
					t	p
Body mass index, kg/m^2						
9th grade	32	21.59±0.38	32	20.74±0.26	1.85	p>0.05
10th grade	24	22.47±0.42	25	21.49±0.32	1.88	p>0.05
11th grade	22	23.18±0.47	23	21.86±0.35	2.25	p<0.05
Vital index, ml/kg						
9th grade	32	49.37±1.03	32	52.21±0.97	2.01	p<0.05
10th grade	24	50.04±1.11	25	54.80±1.02	3.16	p<0.01
11th grade	22	49.95±1.14	23	55.89±1.08	3.78	p<0.01
Strength index, %						
9th grade	32	47.25±0.98	32	51.14±0.92	2.89	p<0.05
10th grade	24	48.19±1.05	25	53.81±0.96	3.95	p<0.001
11th grade	22	49.62±1.09	23	56.53±0.99	4.69	p<0.001
Robinson index, c.u.						
9th grade	32	94.08±1.12	32	90.60±1.05	2.27	p<0.05
10th grade	24	92.47±1.16	25	87.33±1.13	2.56	p<0.05
11th grade	22	90.52±1.19	23	84.74±1.17	3.46	p<0.01
Martine-Kushelevsky test, s						
9th grade	32	141.18±2.63	32	135.25±2.56	1.62	p>0.05
10th grade	24	139.73±2.81	25	131.94±2.69	2.00	p<0.05
11th grade	22	137.86±2.97	23	127.31±2.82	2.58	p<0.05
Level of physical health, points						
9th grade	32	2.98±0.39	32	6.19±0.41	5.67	p<0.001
10th grade	24	3.05±0.44	25	6.84±0.46	5.95	p<0.001
11th grade	22	3.17±0.45	23	7.92±0.47	7.30	p<0.01

Notes: SMG – special medical group; MMG – main medical group; n – number of boys; Mean – arithmetical average; SD – standard deviation; t – Student's t-test value; p – the significance of the difference between the indicators of boys of SMG and MMG

Table 3. Comparative analysis of indicators of morphological and functional development as well as physical health of girls of the 9th-11th grades of the special (n = 85) and main (n = 85) medical groups, Mean±SD

Year of study (grade)	n	SMG	n	MMG	Significance of the differences	
					t	p
Body mass index, kg/m^2						
9th grade	35	21.69±0.25	35	20.09±0.23	4.71	p<0.001
10th grade	27	21.95±0.31	26	19.87±0.26	5.14	p<0.001
11th grade	23	22.07±0.33	24	20.22±0.27	4.34	p<0.001
Vital index, ml/kg						
9th grade	35	45.22±0.86	35	47.82±0.83	2.18	p<0.05
10th grade	27	46.57±0.93	26	50.45±0.87	3.05	p<0.01
11th grade	23	47.39±0.96	24	52.64±0.91	3.97	p<0.001
Strength index, %						
9th grade	35	47.15±0.95	35	49.82±0.89	2.89	p<0.05
10th grade	27	48.19±0.98	26	52.79±0.91	3.44	p<0.01
11th grade	23	49.62±1.02	24	54.11±0.93	3.25	p<0.01
Robinson index, c.u.						
9th grade	35	94.75±1.00	35	91.51±0.94	2.36	p<0.05
10th grade	27	92.33±1.07	26	87.91±1.05	2.95	p<0.01
11th grade	23	91.47±1.11	24	85.13±1.08	4.09	p<0.001
Martine-Kushelevsky test, s						
9th grade	35	145.55±2.80	35	136.72±2.74	2.25	p<0.05
10th grade	27	142.97±2.94	26	134.02±2.88	2.17	p<0.05
11th grade	23	143.04±2.96	24	130.24±2.90	3.09	p<0.01
Level of physical health, points						
9th grade	35	2.15±0.33	35	5.49±0.35	6.94	p<0.001
10th grade	27	2.44±0.38	26	6.22±0.39	6.94	p<0.001
11th grade	23	2.38±0.40	24	7.03±0.41	8.12	p<0.01

Notes: SMG – special medical group; MMG – main medical group; n – number of girls; Mean - arithmetical average; SD – standard deviation; t – Student's t-test value; p – the significance of the difference between the indicators of girls of SMG and MMG

among boys (p<0.05) and 60 ml/kg among girls (p<0.05); in the 10th grade – 4.76 ml/kg among boys (p<0.001) and 3.82 ml/kg among girls (p<0.01); in the 11th grade – 5.94 ml/kg among boys (p<0.001) and 5.25 ml/kg among girls (p<0.001). The life index in the SMG adolescents is assessed as mostly low (boys, 52.6%) and below average (girls, 54.12%), while in the MMG adolescents, it is average (41.2% among boys and 63.5% among girls). This indicates an insufficient level of respiratory system functioning in the SMG adolescents.

The assessment of adolescents' strength capacities showed that in the SMG they are below average both in the boys and girls (87.2% of boys and 90.6% of girls), and in the MMG – at the average level (81.3% of boys and 77.6% of girls). At the same time, it was found that the indicators of the strength index in the SMG adolescents are significantly worse compared to the MMG, by 3.89% among boys (p<0.05) and by 1.77% among girls (p<0.05) in the 9th grade; by 5.62% among boys (p<0.001) and by 4.60% among girls (p<0.01) in the 10th grade; by 6.93% among boys (p<0.001) and by 4.49% among girls (p<0.01) in the 11th grade. The assessment of the functional capabilities of the cardiovascular system of adolescents shows that the Robinson index and the Martine-Kushelevsky test in the SMG are significantly worse than in the MMG (p<0.05-0.001). The difference in the Robinson index between the SMG and the MMG ranges from 3.48-5.78 c.u. among boys and 3.24-6.34 c.u. among girls; in the Martine-Kushelevsky test – 5.93-10.55 s among boys and 8.83-12.80 s among girls. At the same time, the vast majority of adolescents in the SMG have the Robinson index that is below average (88.5% of boys and 89.4% of girls), and in the MMG – as average (51.3% of boys and 58.8% of girls). According to the Martine-Kushelevsky test, the time to restore heart rate to baseline in the vast majority of adolescents in both groups is estimated to be below average.

The level of physical health of the SMG adolescents, as well as most indicators of their morphological and functional development is significantly (p<0.001) worse than that of the MMG adolescents, by 3.21 points in the 9th grade boys, by 3.79 points in the 10th grade and by 4.75 points in the 11th grade. For girls, the difference is 3.34 points in the 9th grade, 3.78 points in the 10th grade, and 4.65 points in the 11th grade. It was found that the level of physical

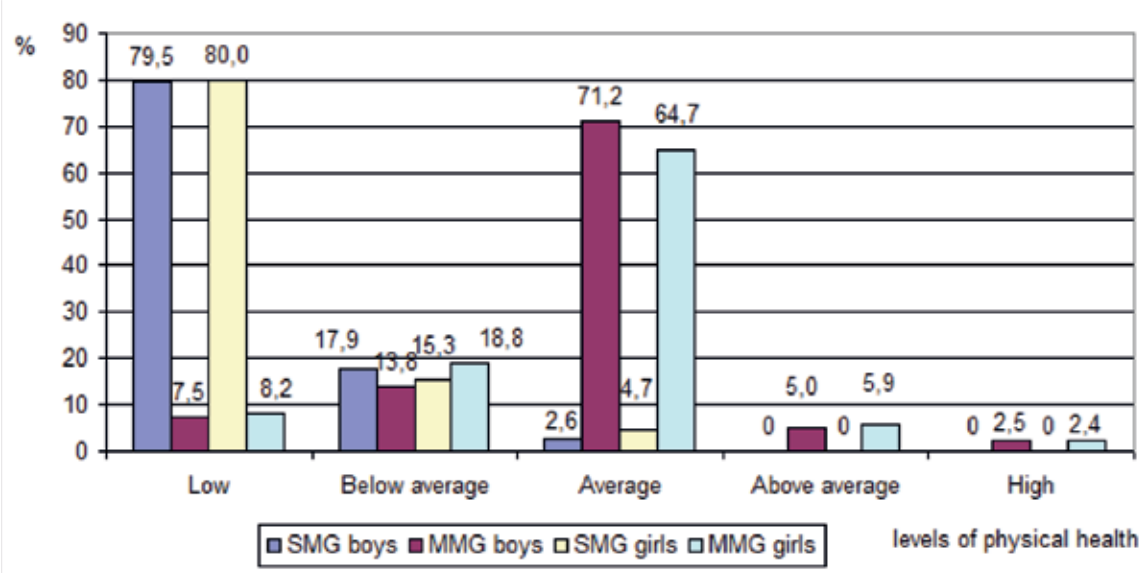

Fig. 1. The proportion of adolescents (boys and girls) in the SMG and MMG with different levels of physical health, %

health of adolescents from the SMG, both boys and girls, is assessed as low, and adolescents from the MMG – as average (Fig. 1).

It is also important to add that with each year of study, the difference between all indicators of morphological and functional development as well as physical health in the SMG and MMG adolescents increases, which confirms the negative trend in the health status of the SMG adolescents. This requires changes in the physical education of high schoolers with health disorders.

DISCUSSION

The foundation for a full life-sustaining activity and future professional activity is the motor experience gained during school years. Therefore, for high schoolers, especially those with disabilities, wellness tasks should be no less important than educational and upbringing ones. At the same time, high schoolers with poor health need qualitatively different motor activities [12]. Scientists [13-15] consider the main tasks of physical education (therapeutic and preventive training sessions) for children with health deviations to be: promoting their health; recovery after diseases; increase of vital activity level, body resistance to influence of adverse environmental factors; enhancement of functional capabilities of an organism, increase of volumes of motor activity; deepening of knowledge in the field of physical culture, formation of motivation to physical exercises.

Physical education at school age is of particular importance for the formation of schoolers' physical health, and motor skills necessary in life and mastering the basics of their practical use. Physical, volitional, and other qualities acquired at school become the basis for mastering various professions in the future. Therefore, it is necessary to take into account the peculiarities of morphological and functional development of children when developing new programs and methods of physical education for the SMG high schoolers. Physical development of adolescents (grades 9-11) is characterized by high intensity, unevenness, and complications. There is increased growth and development of all organs and systems, which is due to the activity of endocrine glands – sex glands, thyroid body, pituitary, etc., hardening of the skeleton, improvement of the muscular system, a significant increase in the intensity of metabolic processes, improvement of the nervous system [16]. During this period, high schoolers' self-awareness and character traits are formed, noticeably manifested in their behavior, frequent mood changes, etc. [17].

It is also worth noting that the motor activity of adolescents with poor health during the day is 20-30% lower than that of healthy children [18]. Insufficient motor activity leads to a decrease in proprioceptive impulses, which causes a deficit of excitation, and impairs the activity of the nervous system, as a result, there is a violation of the nutrition processes of all body systems, a decrease in working capacity, and a lack of physical development [19]. High schooler adolescents with health problems differ from their peers in low body resistance, more frequent diseases, longer disease duration, and lower levels of physical fitness [20]. Our results showed and confirmed the conclusions of other scientists about the low level of morphological and functional development in the 9th-11th grade high schoolers with health disorders and their negative dynamics during school years. All of this should be taken into account when organizing physical education training sessions with the SMG high schoolers to increase their motor activity, promote their health, and form motor experience.

CONCLUSIONS

The level of morphological and functional development as well as physical health of adolescents (9-11 grades) ranking among the SMG was studied, and the data obtained were compared with the indicators of the MMG adolescents and age norms. It was found that according to body mass, vital, strength, Robinson indexes, Martine-Kushelevsky test, and

physical health level, adolescents from the SMG (both males and females) have significantly worse indicators ($p<0.05$-0.001) than adolescents from the MMG. Most indicators of the SMG adolescents are at low and below-average levels, and adolescents from the MMG – are at average levels. At the same time, the dynamics of indicators in the SMG adolescents, unlike the MMG adolescents, tend to deteriorate in the process of schooling. The low level of the studied indicators of morphological and functional development as well as physical health of the SMG adolescents is caused by the presence of diseases, overweight caused by their insufficient motor activity, and irrational organization of physical education at school with high schoolers having health disorders.

The results of the conducted research should be taken into account when organizing physical education training sessions with high schoolers ranking among a special medical group to accelerate their recovery from diseases, increase their motor activity, promote their health, and improve their level of life-sustaining activities.

PROSPECTS FOR FURTHER RESEARCH

It is planned to substantiate and develop a methodology for the physical education of adolescents with health disorders based on a differentiated approach to planning physical activity, taking into account the diseases of adolescents and the peculiarities of their morphological and functional development.

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ORCID AND CONTRIBUTIONSHIP*
Iryna I. Shaposhnikova: 0000-0003-1020-6486[A,B]
Svitlana M. Korsun: 0000-0002-2272-8786[B]
Tetiana A. Malechko: 0000-0001-9430-6745[D]
Roman M. Stasiuk: 0000-0001-6357-6515[C]
Volodymyr M. Serhiienko: 0000-0001-5310-4346[D,C]
Tetiana K. Bondar: 0000-0001-5953-6713[E]
Viktor H. Riabchenko: 0000-0002-5630-9459[F]

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ADDRESS FOR CORRESPONDENCE
Tetiana A. Malechko
Institute of Modernization of the Content of Education
5 Vasyl Lypkivskyi St., 02000 Kyiv, Ukraine
e-mail: tanya.bubley@ukr.net

* Contribution: A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval.

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ORIGINAL ARTICLE

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INFLUENCE OF THE NECK POSTURE ON THE MASTICATORY APPARATUS IN CHILDREN

Stepan O. Lytovchenko, Olexandr V. Pelypenko, Oksana D. Danyliv

POLTAVA STATE MEDICAL UNIVERSITY, POLTAVA, UKRAINE

ABSTRACT

Aim: The study aimed to determine the peculiarities of influence of the neck posture on masticatory apparatus in children.

Materials and Methods: We reviewed lateral cephalometric radiographs of 22 children, 10 girls, and 12 boys (mean age 12 years). Steiner cephalometric analysis and analysis of the upper cervical spine, which was available on corresponding cephalometric radiographs, were performed. In addition to cephalometric analysis, the angle between the McGregor line and the base of C2 (Oc-C2), the angle between the base of C1 and C2, and the angle between C2 and C5 were determined. Spearman's correlation was computed to assess the relationship between neck sagittal plane posture and cephalometry results.

Results: The strong correlation between sagittal neck posture and positioning of the incisor teeth was determined. We found, that the more lordotic is the neck and kyphotic or frontal tilted is the occipital position, the more the position of the incisors is altered towards open bite. Oc-C2 angle had a negative correlation with the Max1-NA (1-NA) angle (r (20) = - 0.63, p = .002), and 1uNA (r(20) = -0.65, p = .001), and positive with interincisor (II) angle (r (20) = 0.55, p = .007). C1-C2 angle had a negative correlation with 1uNA (r(20) = -0.50, p = .017). C2-C5 angle was found to have an opposite relation with incisors: negative correlation with II (r(20) = -0.55, p = .006), positive with Max1-NA (r(20) = 0.44, p = .038), Max1-SN (r (20) = 0.45, p = .031) and Mand1-NB (r(20) = 0.42, p = .048). The upper cervical vertebrae positioning in the sagittal plane is in strong relation with incisors positioning and can be the cause of open bite or vice versa.

Conclusions: Based on cephalometry radiographs analysis we can consider the relation between the neck vertebrae posture and masticatory apparatus to be significant. Neck sagittal alignment is strongly related to the occipital tilt and has a strong correlation with incisors proclining, meaning the increase in spinal lordosis angle is related to forward occipital tilt and an increase in interincisor angle, resulting in upper incisor proclination.

KEY WORDS: orthodontics, orthopedics, pediatric, open bite, posture

INTRODUCTION

Body posture abnormalities has long been recognized as a cause of various craniofacial deformities. In children, as the body is forming during growth, we can suggest the interrelation between malocclusions or other masticatory disorders and postural abnormalities or deformities of the spine or limbs to have a huge diagnostic and therapeutical meaning. Pathological asymmetries and curvatures can be the cause of the compensatory curvatures or deformities elsewhere. The problem of dental and orthopedics comorbidity has been widely discussed in the literature and previously we have estimated in our study that a significant amount of pediatric orthopedic patients have occlusal disorders. Still, there is an obvious lack of evidence regarding the difficulties of interdisciplinary study in making a holistic masticatory apparatus and orthopedic evaluation. Most of the studies, concentrated attention on body balance and posture or strength, and malocclusion by Angle classification, but only some based their study on cephalometry or other radiology imaging methods [1-5].

Collecting better quality evidence of dental and orthopedic interrelation existence or absence will improve our understanding of the body formation process, and will give us new diagnostic and treatment options to provide better orthodontic and orthopedic care for the children.

AIM

Suggesting the existence of an interrelation between malocclusions and cervical spine abnormalities, our study aimed to determine the peculiarities of the influence of the neck posture on masticatory apparatus in children based on the lateral head cephalometric radiographs measurements.

MATERIALS AND METHODS

In our study, 22 children were examined using cephalometric radiography prior to orthodontic treatment. Among the examined were 10 girls and 12 boys. The average age of the examined was 12 years. Radiographs were taken digitally with the patient standing upright in a relaxed pose. Steiner cephalometric analysis and additional analysis of the upper cervical spine, which was available on corresponding cephalometric radiographs, were performed to determine angle variables. On all of the radiographs, the neck was

available for evaluation from C1 to C5 vertebra. Among all possible measurements, we decided to use the Occipital to C2 base angle in which for the occipital part, we used the McGregor line (modification of Chamberlain's line). It is easy to trace the points for McGregor's line and so it provides more reliable results than Chamberlain`s when done by non-radiologist. McGregor line is taken from the most caudal part of the occipital curve to the posterior edge of the hard palate. Next, we have measured the Cobb angle between the C1 and C2 vertebrae. To assess the neck lordosis, we used the Harrison posterior tangential method measurement between C2 and C5, which is not the standard way of determining the cervical spine sagittal posture, but being limited to the number of vertebrae available to analysis on the cephalograms we decided to include this one as it can represent the neck sagittal plane posture too [6, 7].

In Steiner analysis the following points and angles were defined: SNA – angle formed by lines S-N (Sella Turcica point - Nasion) and N-A (Nasion – A-point (subspinale)), SNB – formed by lines S-N and N-B (Nasion - B point (supramentale)), ANB – formed by lines A-N and N-B, SND – formed by lines S-N and N-D (Nasion to D-point (geometric center of the mandible symphysis)), II – interincisal angle, formed by the central axes of the upper and lower medial incisors, namely the lines Ap1u-Is1u and Ar1LIs1L, SN-OcP – formed by lines S-N and OcP (occlusal plane), SN-GoGn – angle formed by lines S-N and Go-Gn (most posterior inferior point on angle of mandible to point located perpendicular on mandibular symphysis midway between pogonion and menton, Max1-Na – angle formed by the central axis of the upper medial incisor, namely the line Ap1u-Is1u and the line N-A, Max1-SN - formed by the central axis of the upper medial incisor, namely the line Ap1u-Is1u and the line S-N, Mand1-NB – formed by the central axis of the lower medial incisor, namely the line Ap1L-Is1L and the line N-B, 1uNA – the distance from the point Ls1u to the line N-A, 1l-NB – the distance from the point Li1L to the line N-B [8] (Fig. 1).

As the statistical evaluation method, we used Spearman's rank correlation coefficient to check our received data on the presence or absence of the interrelation. It was computed using the Wessa, P. Free Statistics Software comparing the values of the neck postural angles (Oc-C2, C1-C2, C2-C5, and cephalometric Steiner analysis results) [9, 10].

The study conformed in all respects to the tenets of the Declaration of Helsinki and was approved by the local Ethics Committee.

RESULTS

Correlation analysis of Steiner cephalometry analysis data and upper cervical vertebrae posture did not reveal significant and reliable relationships between the position of the neck and occipital base and the jaws or facial skeleton deformity (no significant correlation was found between Oc-C2, C1-C2, C2-C5 angles and skeletal Steiner's analysis

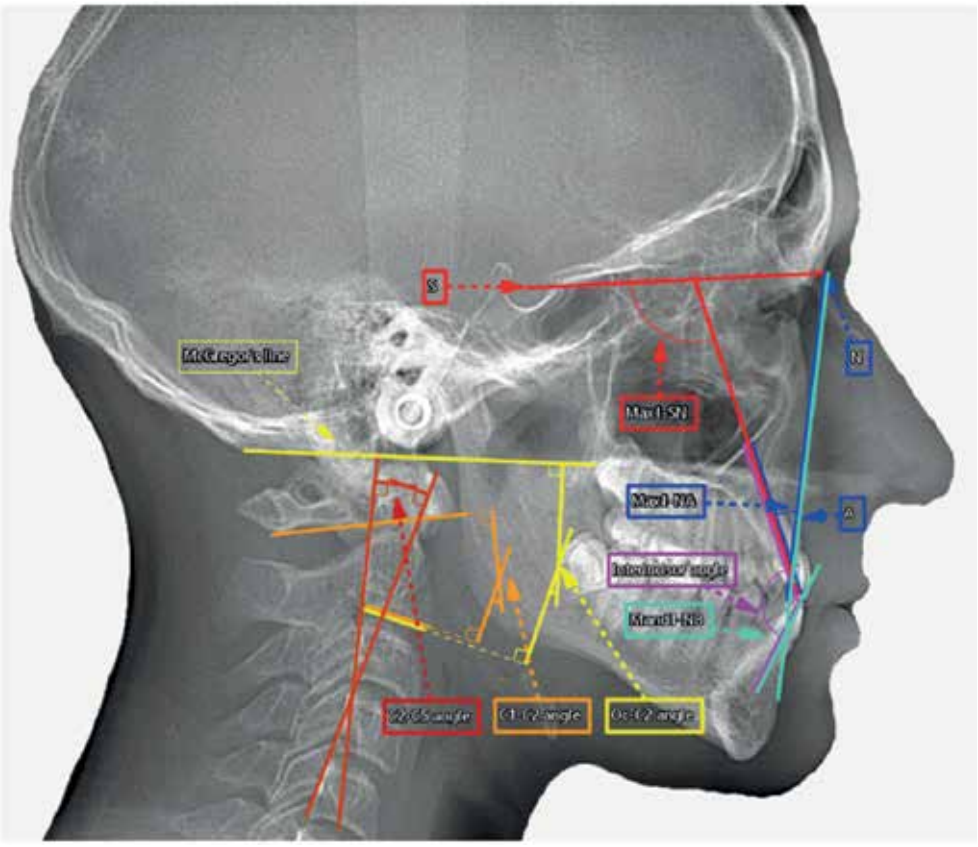

Fig. 1. Steiner cephalometry analysis angles and neck angles that showed significant relation in our study

angles: SNA, SNB, ANB, SND, SN-OcP, SN-GoGn, which describe the skull, maxilla and mandibula form and position) (Fig. 2).

Meanwhile, the strong correlation between sagittal neck and skull posture and positioning of the incisor teeth was determined. We found that the more lordotic was the neck, the more kyphotic or frontal tilted was the occipital position (decreasing in the Occipital-C2 base angle), and the more position of the upper incisors was altered towards proclination and open bite.

Occipital-C2 angle had a negative correlation with the Max1-NA (1-NA) angle, the increase in angle between McGregor`s line and base of the C2 was followed by the decrease in incisors proclination ($r(20) = -0.63$, $p = 0.002$), which decreased the distance between NA and 1 incisor too - 1uNA ($r(20) = -0.65$, $p = 0.001$). A positive correlation was determined between Occipital-C2 angle with II (interincisor) angle ($r(20) = 0.55$, $p = 0.007$) (Fig. 3).

C1-C2 angle had a negative correlation with 1uNA similarly to Oc-C2 ($r(20) = -0.50$, $p = 0.017$). C2-C5 angle was found to have an opposite interrelation with incisors: increase of C2-C5 angle was followed by decrease of interincisal angle, showing negative correlation C2-C5 with II ($r(20) = -0.55$, $p = 0.006$), C2-C5 angles had a moderate positive correlation with Max1-NA ($r(20) = 0.44$, $p = 0.038$), Max1-SN ($r(20) = 0.45$, $p = 0.031$) and Mand1-NB ($r(20) = 0.42$, $p = 0.048$) (Fig. 4).

Regarding the above-mentioned correlations, we decided to check the correlation between Oc-C2 and C2-C5 angles, considering the opposite relationship between them. The Oc-C2 and C2-C5 angles Spearman correlation test indicated that there was a significant negative association between that neck angles, ($r(22) = -0.78$, $p = 0.001$) (Fig. 5).

DISCUSSION

Negative correlation between C2-C5 angle representing neck lordosis and Oc-C2 angle representing occipital positioning which together have opposite correlations with the incisors positioning (negative for Oc-C2 and positive for C2-C5) is, while intuitively understandable, hard to realize. Because of the complexity of the highly mobile cervical spine and head, with numerous coacting joints and muscles, minor changes in one part can induce changes in the other.

In previous studies, the correlation between neck vertebrae morphology and craniofacial morphology have been found. In 2014 study, E. Segato found that the vertebral bodies of the upper neck are closely related with the morphology of the mandibular [11]. According to Weiguo Zhu, et al. (2018), the occipital orientation was an important factor that influenced the cervical sagittal alignment [12]. Similar results were found in our study, showing the correlation between Oc-C2 and C2-C5 angles. Regarding the masticatory apparatus posture and the neck posture interrelation, M.Waseem et al. showed that there is a significant association between oral breathing and neck lordosis alteration [13].

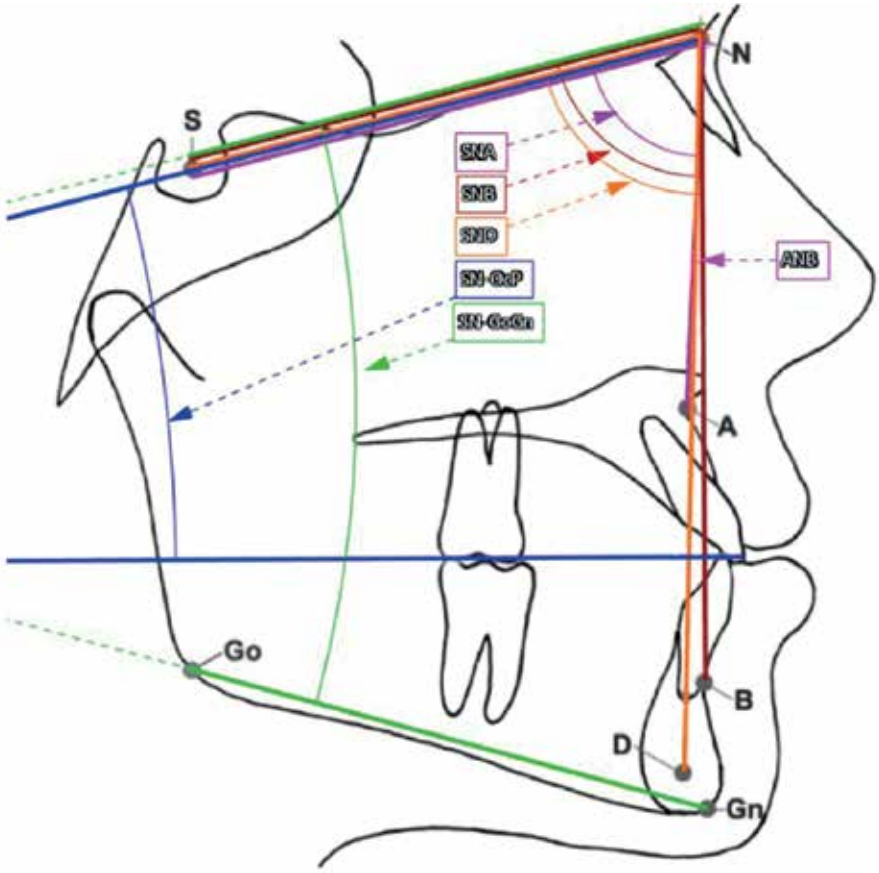

Fig. 2. Steiner skeletal angles

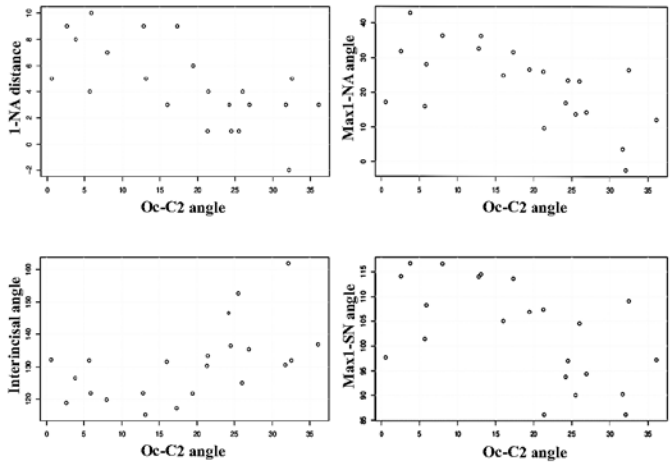

Fig. 3. Scattered plots of the significant Spearmen`s correlation between Oc-C2 angle and cephalometry angles

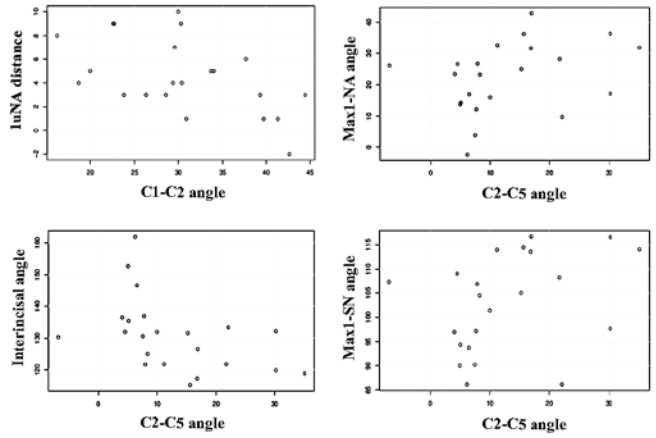

Fig. 4. Scattered plots of the significant Spearmen`s test correlation between C1-C2 and C2-C5 angle and the cephalometry angles

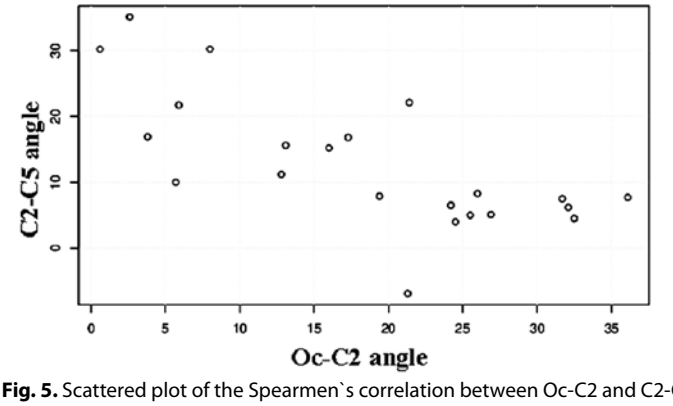

Fig. 5. Scattered plot of the Spearmen`s correlation between Oc-C2 and C2-C5 angles

Teeth positioning can be influenced by the neck posture or neck posture is the result of the incisors position? Our study suggests existing correlation between incisors proclination and forward occipital tilt and C2-C5 lordosis, but it don't give a clear answer to above mentioned question. Although interrelation between teeth and neck was previously studied and showed to be significant, but for better understanding of the nature of this relation we are lacking the quality studies which will evaluate the influence of the orthodontic treatment of the open bite on the neck and occipital posture.

Such studies as these are of high value to estimate the influence of the head positioning on the dental health in children. The changes in lifestyle and postural habits which are related, for example, with the smartphone usage,

or other hobbies or habits, like oral breathing or thumb sucking that possibly can induce changes in the cervical spine posture, can be used for prediction of the permanent teeth positioning and bite formation.

Our study was limited due to the relatively small number of participants (n=22) and due to the inability to make the C2-C7 measurements of the neck lordosis associated with different amount of the cervical spine captured on the cephalography radiographs. Nevertheless, the results obtained showed enough statistical significance and reliability, keeping the logic that the angle between the C2 and C5 vertebrae is as much an indicator of cervical lordosis as the angle between C2 and C7 vertebrae.

CONCLUSIONS

Based on cephalometry radiographs analysis we can consider the relation between the neck vertebrae posture and masticatory apparatus to be significant. Neck sagittal alignment is strongly related to the occipital tilt and has a strong correlation with incisors proclining, meaning the increase in spinal lordosis angle is related to forward occipital tilt and an increase in interincisor angle, resulting in upper incisor proclination.

Further study is required to evaluate the influence of the other spine segments' posture on the head and teeth positioning and their influence on the masticatory apparatus in general.

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ORCID AND CONTRIBUTIONSHIP*
Stepan O. Lytovchenko: 0000-0002-5839-1978[A,C,D]
Olexandr V. Pelypenko: 0000-0002-9010-3163[E, F]
Oksana D. Danyliv: 0000-0003-1902-809X[B]

CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ADDRESS FOR CORRESPONDENCE
Stepan O. Lytovchenko
Poltava State Medical University
23 Shevchenko St., 36000 Poltava, Ukraine
e-mail: stepan.lytovchenko@outlook.com

* Contribution: A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval.

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EFFICACY OF DENTAL BLEACHING WITH DIODE LASER, LED IRRADIATION AND CHEMICAL ACTIVATION SYSTEM: A COMPARATIVE STUDY

Nataliia G. Gadzhula, Mariia M. Shinkaruk-Dykovytska, Anastasiia V. Povsheniuk, Tetiana O. Rekun, Nataliia M. Isakova

NATIONAL PIROGOV MEMORIAL MEDICAL UNIVERSITY, VINNYTSIA, UKRAINE

ABSTRACT

Aim: To compare the effectiveness and safety of various methods of professional teeth bleaching using light and chemical activation systems in an in vivo study.

Materials and Methods: Teeth whitening was performed on 48 patients aged 20 to 35, divided into 4 groups. In patients of group 1 for dental bleaching a diode laser activation was used, group 2 – LED/gel activation, group 3 – chemical whitening with the following remineralization therapy, group 4 – chemical whitening without remineralization therapy. The study of the effect of bleaching systems on the hard tooth tissues was carried out by index assessment, determination of biochemical parameters of an oral fluid.

Results: Laser bleaching of the vital teeth was significantly more effective than the other methods with 95% confidence level and did not affect the structure of hard dental tissues and mineral exchange of the oral fluid. LED irradiation has a high whitening effect, but leads to dentin hypersensitivity and a decrease in phosphorus and alkaline phosphatase of oral fluid. Chemical bleaching causes a decrease in enamel resistance, the occurrence of tooth sensitivity, violation of mineral exchange of oral fluid, therefore; it requires combined use with local remotherapy.

Conclusions: Laser teeth bleaching is the effective and safe method in management of discolored teeth. A positive result of its use can be considered an improvement of color change of the teeth by 3.33 shades compared to chemical bleaching, enamel stability, low values of dental hypersensitivity indices, no changes in biochemical parameters of the oral fluid.

KEY WORDS: laser teeth bleaching, tooth discoloration, oral fluid, mineral metabolism

INTRODUCTION

A change in the color of the teeth, or tooth discoloration, leads to a violation of smile aesthetics and, as a result, adversely affect a person's self-esteem, social adaptation, and psychological state. Tooth discoloration is divided into congenital and acquired, extrinsic (temporary) and intrinsic (permanent). Most of them are successfully removed using one method, for others there is a need for the combined use of different methods. Despite the high demand for teeth bleaching, the safety issue of various methods for removing tooth depigmentation has not been completely resolved. A significant disadvantage of bleaching systems, especially with a high concentration of hydrogen peroxide (HP) and a low pH value, is their side effect on the dental hard tissues, which leads to demineralization and dehydration of tooth tissues, a decrease of the enamel microhardness, the release of macro- and microelements from the superficial enamel layer, and a decrease of resistance to abrasion, occurrence of dentin hypersensitivity [1, 2]. According to the results of numerous studies, peroxide agents used in office tooth bleaching systems can affect not only the enamel, dentin and pulp of the tooth, but also can change the mineral metabolism and the activity of some enzymes in the oral fluid [3], although in publications about this there are conflicting data.

Light or heat sources are used to accelerate the oxidation-reduction reaction of the bleaching gel due to faster decomposition of HP and the formation of free radicals. One of the methods of activation during professional bleaching of discolored teeth is power bleaching with high-intensity light [4]. Implementation of laser systems into dental practice [5-7], which are also actively used in the bleaching algorithm of discolored teeth, occupies an important place in the development of effective and safe bleaching methods [1, 8]. Currently, there are conflicting reviews about laser bleaching efficiency and its effect on the tooth, that needs additional research.

AIM

To compare the effectiveness and safety of various methods of professional tooth bleaching using light and chemical activation systems in an in vivo study.

MATERIALS AND METHODS

Tooth bleaching was performed in 48 patients aged 20 to 35 years. The inclusion criteria were the following:

discolored teeth of various etiology, age-related changes in the color of tooth enamel, aesthetic preferences of the patient. The exclusion criteria were: the presence of dental hypersensitivity, carious cavities, exposed necks and roots of the teeth, periodontal diseases and oral mucosal diseases, a wide pulp chamber, orthopedic and orthodontic appliances, significant loss of enamel as a result of pathological or age-related tooth wear, taking light-sensitive medicines, oncological and endocrine diseases, bronchial asthma, pregnancy.

Before the start of the bleaching procedure, all patients underwent professional oral hygiene, the enamel remineralization index and enamel resistance test (TER-test), as well as parameters of the mineral exchange of oral fluid, were determined. Participants of the study were divided into 4 groups with a similar dental status of 12 patients in each with the same distribution of colors according to the VITA scale ("VITA Zahnfabric", Germany). In group 1 the teeth were bleached with diode laser Picasso 7Wt "AMD Lasers, USA" with a power of 1.6 W and a wavelength of 808 nm (the standard fourth program of the pulsed radiation mode of the device) after a single applying of JW Power Bleaching NEXT gel ("Heydent", USA) with 30% HP content. Patients of group 2 underwent light-emitting diode (LED) bleaching with a wavelength of 470 nm using the Bleach'n smile AUTOMIX system (Schutz Dental, Germany) with 35% HP content. In patients of groups 3 and 4, in-office teeth whitening was performed chemically with the use of Opalescence Extra Boost gel ("Ultradent", USA) with 40% HP three sessions for 20 minutes. After bleaching, in patients of group 3 a remineralization therapy lasting 20 minutes daily for 10 days was carried out with applying of two-component gel which includes calcium phosphate salts and fluorides.

The evaluation of the efficiency of dental bleaching was carried out on the 10th day in visual analysis according to the expanded VITA shade guide. The study of the effect of the bleaching systems on the hard tooth tissues was evaluated immediately and in 10 days after the bleaching procedure according to TER-test, enamel remineralization index, prevalence and intensity of tooth sensitivity indices, Schiff test.

The content of calcium (Ca), phosphorus (P), magnesium (Mg) and alkaline phosphatase (AP) in the oral fluid was determined before vital tooth bleaching, right after the bleaching procedure and in 10 days by the photometric method using a KONE "Specific Basic" biochemical analyzer (Konelab Corporation, Finland) with the standard sets of reagents and control serumes Abtrol, Nortrol and "SERODOS plus HUMAN" (Germany). Ca concentration was determined by Arsenazo III method, P content was measured by Molybdate method, magnesium – by Xylidyl Blue I. AP activity was determined using diethylamine buffer (SCE).

The study was approved by the Biomedical Ethics Committee of National Pirogov Memorial Medical University, Vinnytsya (protocol No. 4 dated May 18, 2023) and complies with Declaration of Helsinki (2013). All patients gave their written voluntary informed consent to research their data.

The statistical data analysis was carried out using the methods of variation statistics with "Statistica 6.1" software (serial number BXXR901E246022FA) and Microsoft® Excel 2017 for Mac (corporate license, product ID: 02984-001-000001, device code: 86C36D0C-8F15-59CA-A81E-B1D889205F71). For descriptive statistics, average arithmetic and relative mean values and standard errors of the mean (M±m), (P±m), standard deviation (σ) and the significance of differences (p-value) were used. The reliability of the obtained results was assessed by Student's t-test; the differences were considered statistically significant in $p<0.05$.

RESULTS

The obtained results of the clinical study showed that all bleaching systems were effective in removing of discolored vital teeth. Thus, color change of the teeth in group 1 occurred by 7.58±0.73 shades, in group 2 – by 5.92±0.80 shades, in group 3 – by 4.25±0.39 shades, in group 4 – by 4.08±0.44 shades (Table 1).

As a result of the study of the structural and morphological composition of superficial layer of enamel after tooth bleaching, it was seen that in patients of groups 1 and 3, TER-test scores did not differ significantly from the initial values (3.71±0.18; 3.80±0.17, $p>0.05$). In participants of group 2, an increase of TER-test values to 4.45±0.19 ($p<0.01$) was observed. The maximum average statistical values of TER-test were revealed in patients of group 4 – 4.65±0.20 ($p<0.01$), which indicates a decrease in enamel resistance after tooth bleaching without the involvement of remineralization therapy. In 10 days of follow-up, the value of the test decreased to 3.94±0.19 in group 2 ($p>0.05$) and to 4.22±0.20 in group 4, but did not reach the baseline ($p_1<0,01$).

The index of enamel remineralization in participants of groups 1 and 3 did not change statistically significantly compared to baseline ($p>0.05$). In group 2 after LED/gel activated the index values increased from 2.72±0.09 to 3.17±0.13 scores in $p<0.05$. In group 4 after chemical bleaching without prior and subsequent remotherapy, the index values increased significantly compared to the initial data and the values of other groups to 3.28±0.13 scores in $p<0.01$.

Evaluation of clinical symptoms after the bleaching procedure revealed increased tooth sensitivity in all groups of examined patients. In participants of groups 1 and 3 were revealed the significantly ($p<0.001$) lower values of the prevalence and intensity index of hypersensitivity than in groups 2 and 4. The highest degree of teeth sensitivity lasting 24 hours was observed after LED/gel activated. In this group, an increase in enamel permeability was accompanied by increased tooth sensitivity: 17,02±3,58% and 2.03±0.06 scores immediately after bleaching and 5,50±1,71% and 1.34±0.05 scores in 10 days after the end of the procedure. In patients of group 4 localized tooth sensitivity of the 2nd degree prevailed, the prevalence index of hyperesthesia increased to 15,89±2,87%. Similar tendency was observed when determining the intensity

Table 1. The effect of various methods of professional tooth bleaching on the hard tooth tissues

Indices	Before bleaching	Group 1 n=12	Group 2 n=12	Group 3 n=12	Group 4 n=12
Color change, shades		7.58±0.73	5.92±0.80	4.25±0.39**	4.08±0.44**
TER-test	3.62±0.18	3.71±0.18	4.45±0.19*	3.80±0.17	4.65±0.20*
TER-test in 10 days		3.66±0.17	3.94±0.19	3.60±0.18	4.22±0.20*
Index of enamel remineralization	2.72±0.09	2.78±0.11	3.17±0.13*	2.83±0.12	3.28±0.13*
		2.70±0.12	2.95±0.13	2.65±0.11	3.25±0.12*
Index of prevalence of hyperesthesia, %	0	3.94±1.67*	17.02±3.58*	4.46±1.63*	15.89±2.87*
		1.04±0.73	5.50±1.71*	1.59±0.87	4.98±1.48*
Intensity index of hyperesthesia, scores	0	0.92±0.07*	2.03±0.06*	1.14±0.06*	1.67±0.05*
		0.09±0.06	1.34±0.05*	0.11±0.09	1.14±0.05*
Schiff index, scores	0	1.08±0.16*	2.75±0.19*	1.0±0.18*	2.50±0.20*
		0.08±0.09	1.33±0.15*	0.17±0.12	1.67±0.23*

*Note: * – significance of the difference between the baseline values and parameters after tooth bleaching; ** – significance of the difference between group 1 and other groups.*

index of tooth sensitivity: the values increased to 1.67±0.05 scores. In 10 days, the index values decreased to 4,98±1,48% and 1.14±0.05 scores, but did not reach the baseline and according to the qualitative assessment corresponded to "localized tooth sensitivity of the 1st degree".

The average value of Schiff's sensitivity digital rating scale in group 1 was 1.08±0.16 scores immediately after laser whitening (11/12) and 0.08±0.09 scores (1/12) on the 10th day of follow-up. During the patients' examination of group 2, the Schiff index was 2.75±0.19 scores (12/12), during the repeated examination – 1.33±0.15 scores (10/12), mainly in the frontal group of teeth ($p<0.001$). In group 3, where chemical whitening was performed in combination with remotherapy, the Schiff score was 1.0±0.18 (10/12) immediately after whitening; 10 days later slight tooth sensitivity was diagnosed in 2 patients (0.17±0.12). In patients of group 4 with chemical bleaching in the absence of remineralization therapy, the Schiff score was 2.50±0.20 (12/12) after the bleaching procedure and 1.67±0.23 (11/12) during final examination.

The dynamics of Ca, P, Mg and AP in mixed saliva during vital tooth bleaching were within normal limits (Table 2). The highest values of Ca concentration in the oral fluid were registered in participants of group 4 after chemical bleaching (1.29±0.03 mmol/l, $p<0.05$). At the same time, a significant reduction of P content was observed to 5,19±0,20 mmol/l in group 2 and to 5,09±0,20 mmol/l in group 4 compared to baseline ($p<0.05$). A change in the concentration of the main mineral components of oral fluid, necessary for physical and chemical exchange in enamel, contributed to a significant increase in the Ca/P ratio in mixed saliva. However, the reliability of the difference in the Ca/P ratio was revealed only in patients of group 4 ($p<0.05$).

Ca level returned to baseline in 10 days. There was no significant difference in the changes in Ca after tooth bleaching procedure between all groups. A decrease in P content was observed immediately after tooth bleaching, and 10 days later, the P level returned to baseline. The ratio of Ca/P in the oral fluid increased right after tooth bleaching procedure and returned to baseline values 10 days later, reflecting the changes of Ca and P content in oral fluid. After professional tooth whitening, the concentration of Mg in group 4 significantly decreased compared to baseline ($p<0.05$). In groups 2 and 4 there was a significant reduction ($p<0.01$) of AP activity: 3.25±0.23 EU/l and 2.92±0.22 EU/l. Obviously, a significant decrease of Mg concentration in group 4 leads to a compensatory reduction in the activity of AP.

Table 2. Dynamics of biochemical parameters of the oral fluid after vital tooth bleaching

Biochemical parameters	Before tooth bleaching	Group 1 n=12	Group 2 n=12	Group 3 n=12	Group 4 n=12
Ca, mmol/l	1.19±0.02	1.20±0.02	1.22±0.03	1.18±0.02	1.29±0.03*
P, mmol/l	5.90±0.21	5.85±0.22	5.19±0.20*	5.98±0.20	5.09±0.20*
Ca/P ratio	0.210±0.006	0.211±0.009	0.235±0.011	0.198±0.07	0.255±0.010*
Mg, mmol/l	0.53±0.05	0.51±0.05	0.41±0.04	0.55±0.05	0.35±0.04*
AP, EU/l	4.17±0.26	4.02±0.25	3.25±0.23*	4.11±0.26	2.92±0.22*

*Note: * – significance of the difference between the baseline values and parameters after tooth bleaching.*

Thus, as can be seen from the given data of oral fluid research, we have the opportunity to note significant changes in the content of Ca, P, Mg and AP in group of patients who underwent chemical bleaching ($p<0.05$), which was clinically confirmed by dental hypersensitivity of the 2nd degree and high TER-test values. The level of biochemical parameters of the oral fluid returned to baseline values on the 10th day of follow-up. The stability of Ca, P, Mg and AP content during all stages of follow-up can be considered a positive result of the use of remineralization therapy in study participants of group 3.

DISCUSSION

Laser bleaching was the most effective method, chemical bleaching had a minimally pronounced whitening effect, and LED/gel activated occupied an intermediate position. In the scientific studies [9, 10], it was found that tooth bleaching did not improve when using additional light sources (halogen lamps, LED lamps, laser), but the results of our study showed that the light-activated system provides better whitening efficiency, than chemical activation system. Our data are consistent with the study [1, 4], in which is listed that in laser bleaching absorption by the bleaching gel is directed to the ionization of HP, and this depends on the specific wavelength required for direct photolysis or photooxidation of chromophores in dentin.

Various scientists have studied the effect of bleaching agents on enamel surface roughness. The obtained results regarding the safety of the bleaching procedure with the use of a diode laser were confirmed in studies [1], in which the unchanged enamel surface after whitening and the absence of changes in the dentine structure were demonstrated, and no significant differences in the enamel microhardness before and after treatment were seen.

The results of our study showed high values of the remineralization index and TER test in the groups after chemical bleaching and LED/gel activation, indicating a decrease in enamel resistance due to the demineralizing effect of the bleaching gel on the dental tissues.

Increased tooth sensitivity after the professional bleaching procedure was revealed in all groups of the examined. The highest degree of dental hypersensitivity was observed after photobleaching, which necessitates the use of remineralizing therapy. The lowest tooth sensitivity occurred in the group of patients after laser tooth bleaching. Our data are consistent with the study of Mondelli et al. [9], in which a comparative analysis of teeth whitening with the a diode laser (810 nm, 37% HP), LED activation (400-500 nm, 38% HP) and without light activation (38% HP). According to the reports of authors, the lowest sensitivity was seen for diode laser usage, which decreased in 24 hours after bleaching and returned to normal in 7 days.

Demineralization and Ca loss from the tooth surface usually occurs in organic tissues and hydroxyapatite crystals during bleaching. It has been established that under the influence of various bleaching systems and methods, the organic matrix of inter-enamel prisms is discolored, as well as a slight releasing of Ca and P, due to which the pores expand in the superficial and deep enamel layers [11]. Research of the effects of tooth bleaching systems has shown that the concentration of some parameters of mineral metabolism and the activity of AP changes in the oral fluid. The most pronounced increase of Ca concentration, as well as a decrease in the level of P, Mg and AP activity in the oral fluid after bleaching occurred when using a chemical activation system with 40% HP. The studied parameters in 10 days stabilized and were not significantly differ from the baseline, which can be explained by the gradual mineral recovery of hard tooth tissues due to the remineralizing potential of saliva.

The analysis of oral fluid parameters after chemical bleaching with the following remineralization therapy in patients of group 3 showed that the use of remineralizing agents provides the stability of the content of Ca, P, Mg and higher activity of AP in mixed saliva than in other groups of the examined. Along with this, when using laser bleaching, changes in levels of Ca, P, Mg and AP in the oral fluid were also not seen. The obtained results agree with literature data of Parreiras et al. [12], in which it was confirmed that no significant differences in Ca and P concentration were observed after 830 nm laser bleaching.

CONCLUSIONS

1. Laser teeth bleaching is the effective and safe method in management of discolored teeth. A positive result of its use can be considered an improvement in tooth color change by 3.33 shades compared to chemical bleaching, enamel stability, low values of dental hypersensitivity indices, no changes in biochemical parameters of the oral fluid.
2. LED irradiation contributes to a high improvement in the brightness of teeth, but leads to a significant decrease of enamel resistance, the occurrence of dentine hypersensitivity, a significant reduction in the level of P and AP in the oral fluid.
3. An increase in enamel resistance, low values of the prevalence and intensity of tooth sensitivity indices, stability of Ca, P, Mg and higher activity of AP in oral fluid were revealed in the group of patients when vital tooth bleaching was combined with remotherapy usage.
4. Elimination of tooth discoloration by a chemical method causes violation of the mineral content of oral fluid, a decrease of enamel resistance, the occurrence of dental hyperesthesia, therefore it requires mandatory combined use with local remineralizing therapy at all stages of bleaching.

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ORCID AND CONTRIBUTIONSHIP*

Nataliia G. Gadzhula: 0000-0003-0016-2264[A,B,D]
Mariia M. Shinkaruk-Dykovytska: 0000-0002-0747-4247[E,F]
Anastasiia V. Povsheniuk: 0000-0002-6799-9627[B,E]
Tetiana O. Rekun: 0000-0003-1183-7028[B,E]
Nataliia M. Isakova: 0000-0002-3037-9651[B,C]

ADDRESS FOR CORRESPONDENCE

Nataliia G. Gadzhula
National Pirogov Memorial Medical University
56 Pyrohov St., 21018 Vinnytsia, Ukraine
e-mail: gadzhula@vnmu.edu.ua

CONFLICT OF INTEREST

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RULES OF A HEALTHY LIFESTYLE AND PECULIARITIES OF THEIR COMPLIANCE AMONG STUDENT YOUTH

Natalia A. Lyakhova[1], Nataliia A. Dakal[2], Tetiana V. Napalkova[3], Larysa V. Anikeienko[2], Viktor P. Bilokon[2], Serhii M. Soha[2], Volodymyr E. Dobrovolskyi[2]

[1]POLTAVA STATE MEDICAL UNIVERSITY, POLTAVA, UKRAINE
[2]NATIONAL TECHNICAL UNIVERSITY OF UKRAINE "IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE", KYIV, UKRAINE
[3]NATIONAL UNIVERSITY "ZAPORIZHZHIA POLYTECHNIC", ZAPORIZHZHIA, UKRAINE

ABSTRACT

Aim: To characterize the basic rules of a healthy lifestyle and to study the peculiarities of their compliance among student youth.

Materials and Methods: The research involved 219 students (121 males and 98 females), of whom 123 students were in the 1st instructional year and 96 students were in the 4th instructional year. Methods: analysis and generalization of literary sources, questionnaires, and mathematical statistics.

Results: The basic rules of a healthy lifestyle were characterized and the peculiarities of their compliance among students were investigated. It was found that more than 70% of students, regardless of gender, smoke, and more than 60% drink alcohol. Less than half of the surveyed students adhere to a rational daily routine; less than 20% of students do physical exercises; less than 30% of students attend sports clubs; less than 20% of students follow sensible nutrition. All these indicators tend to deteriorate during the 4th instructional year.

Conclusions: It was found that the vast majority of students do not follow the rules of a healthy lifestyle during their studies, which indicates that higher educational institutions do not pay enough attention to the formation of the necessary knowledge, skills, and abilities in students' lifestyles and that students are not motivated to follow the rules of a healthy lifestyle in the learning process. All of this can negatively affect the effectiveness of their educational and future professional activities, as well as their health.

KEY WORDS: health, healthy lifestyle, rules, students

INTRODUCTION

According to the WHO, human health depends on environmental conditions by 25%, genetic factors by 15-20%, adequacy of the health care system by 10-15%, and lifestyle and conditions by 50-55% [1]. It is the lifestyle, or rather a healthy lifestyle, that affects all indicators of human life-sustaining activities (the effectiveness of educational and professional activities, family well-being, relationships with other people, etc.) [2]. Today, many people, including young people, talk about a healthy lifestyle, although not everyone well understands the basic essence of this concept and reduces it to quitting bad habits or doing sports, which undoubtedly also has a significant impact on health. A healthy lifestyle is a way of life and thinking [3, 4]. Lifestyle is not only the nature of human behavior that has a positive or negative impact on health. The very nature of behavior is determined by the physical and cultural environment, upbringing, and material opportunities. Lifestyle formation is influenced by stereotypes of relationships between people, their life experience, and social conditions and environment [5].

Today, the main social and biological approaches to organizing of a healthy lifestyle have been formed, namely [6, 7]: social (lifestyle should be aesthetic, moral, and volitional); biological (lifestyle should be energizing, strengthening, rhythmic and meet age characteristics). According to the literature [8-10], it has been established that the basic rules of a healthy lifestyle include: a harmonious regimen, a combination of work and rest; optimal nutrition; physical activity; hygiene; absence of bad habits; a friendly attitude to others and life in general. Scientists supplement this list of healthy lifestyle rules with the following: sleep hygiene, hardening and outdoor walks, psychophysical self-regulation of the body (ability to withstand stress), sexual culture (sexual life and safe sexual behavior), productive life (satisfaction from the day, positive emotions, intellectual development), mastery of elementary methods of self-control, medical control (preventive examinations). Adherence to these rules of a healthy lifestyle has its peculiarities in relation to different categories of the population and depends on gender, age, etc.

AIM

The aim is to characterize the basic rules of a healthy lifestyle and to study the peculiarities of their compliance among student youth.

Objectives: 1) to reveal the essence of healthy lifestyle rules; 2) to study the peculiarities of compliance of healthy lifestyle rules among student youth.

MATERIALS AND METHODS

The research was conducted in 2021-2022 at the Department of Health and Sports Technologies of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (Kyiv, Ukraine). The research involved 219 students (121 males and 98 females), of whom 123 students (66 males and 57 females) were in the 1st instructional year and 96 students (55 males and 41 females) were in the 4th instructional year.

Methods: analysis and generalization of literary sources, questionnaires, and mathematical statistics. The method of analysis and synthesis contributed to the study of the literature on the topic of the research (23 sources from the databases PubMed, Scopus, Web of Sciences, Index Copernicus and others were investigated), the main focus was on the systematization of healthy lifestyle rules. The survey was conducted using the authors' questionnaire, which contained 5 questions about students' compliance with the basic rules of a healthy lifestyle (quitting bad habits, following a rational daily routine, physical activity, sensible nutrition, compliance with health monitoring (regular medical examinations)). The survey was anonymous and conducted in compliance with all the requirements for sociological research. Questionnaire was assessed by the experts in this field (4 professors and 5 associate professors) and was approved by the Academic Council of National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (Protocol No. 2 dated 06.09.2021). Consent to voluntary participation in the survey was obtained from all the students involved in the study.

The methods of mathematical statistics were applied to correctly process the data and identify the difference between the indicators under study. The compliance of the data distribution with the Gauss' law was assessed using the Shapiro-Wilk W-test. The authenticity of the difference between the indicators that were evaluated in percentages was determined by means of Chi-square (χ^2) Pearson's criterion (T). The statistical significance for all statistical tests was set at $p<0.05$. All statistical analyses were performed with the SPSS software, version 21, adapted to medical and biological researches. This research followed the regulations of the World Medical Association Declaration of Helsinki and ethical principles for medical research involving human subjects. Informed consent was received from all students who took part in this research.

RESULTS

The essence of the basic rules of a healthy lifestyle is given below.

Quitting bad habits. Different types of addictions negatively affect human health, including tobacco smoking (according to the WHO, Ukraine ranks 17th among the countries of the world in terms of tobacco smoking), drinking alcohol (more than 100,000 alcohol addicts are registered in Ukraine every year), and drug addiction (about 1.5-2 million people with drug addiction are registered in Ukraine). Bad habits and addictions have a detrimental effect on the body at any age. The impact is especially harmful during adolescent period, as the body is formed and grows to its maximum capacity by the age of 19. When the body is exposed to nicotine, alcohol, and drugs, irreversible reactions occur, leading to stunted growth, decreased immunity, mental disorders, and increased risks of morbidity. The motivation to give up bad habits is usually minimal because a teenager imitates his or her friends when they are among them.

A daily routine is a rational plan of action throughout the day. It is conditionally divided into 4 parts: sleep, physical activity, mental activity, and free time. It is recommended to choose the period of highest activity for work i. e. morning and afternoon. During work, it is necessary to take rest breaks, the number of which is determined by the severity of mental or physical work.

Sleep should last for different amounts of time in different periods of life. Normally, an adult should sleep at least 8-9 hours a day, children – 9-10 hours, the elderly – 7-8 hours.

Personal hygiene is a set of hygienic rules that help to promote and preserve human health and increase the duration of active life. This is a necessary set of measures in terms of caring for the face, body, hair, and clothing, which helps to maintain health and brings a sense of satisfaction with one's appearance. The internal environment of the home is formed as a result of the interaction of many physical, chemical, and biological factors that affect human health. In this case, the availability of sufficient fresh air is important, so the premises need regular ventilation and wet cleaning. Solving hygienic problems in the younger generation involves creating healthy, hygienic living, learning, and education conditions.

The amount of motor activity is one of the most important rules of a healthy lifestyle. Motor activity and systematic physical load improve the physical and psycho-emotional state of a person, allow them to achieve fitness, and increase their performance.

Hardening is a gradual adaptation of the body to stressful environmental conditions. The basic rules of hardening include sun and air baths, dousing, rubbing, open water, and ice hole swimming. Hardening as a principle of a healthy lifestyle is of great importance for promoting health, increasing resistance to infections, and enhancing efficiency. The essence of hardening is to train the thermoregulatory apparatus, increase the body's adaptive capacity, stress resistance and develop the body's protective reactions to the damaging effects of certain environmental factors.

Walking in the fresh air is one of the factors that boosts human immunity. During a walk, a person not only breathes in clean air but also takes sunbathing, which produces vitamin D.

Sensible nutrition is one of the main factors that significantly affects the body's condition and is an integral part of a healthy lifestyle of a modern person who cares about his or her physical fitness and well-being. It is necessary to adhere to the principles of nutrition: regularity, balance, and usefulness (food should not contain harmful substances). Sensible nutrition involves eating high-quality foods that contain a sufficient amount of fats, proteins, and carbohydrates. The choice of food depends on the age

and health of the person. At a young age, the body needs a significant amount of proteins and vitamins. During this period, the motivation for proper nutrition is the desire to please the opposite sex, to have an athletic body and an attractive appearance. Over time, the consumption of meat products should be reduced, and the amount of calcium-containing foods, vegetables, and fruits should be increased. There are also restrictions on the consumption of certain foods for people with chronic diseases. In this case, the motivation for proper nutrition is to prevent the recurrence of the disease and improve overall health.

Psychophysical self-regulation of the body involves avoiding stress and managing it effectively. After all, stress is a state of the body that manifests itself in the form of tension or specific adaptive reactions in response to adverse external or internal factors.

Sexual life is one of the most important physiological needs of a person, the satisfaction of which depends on his or her psycho-emotional state and the functioning of many organs and systems. Regular sexual relations as a principle of a healthy lifestyle improve a person's psycho-emotional state, boost immunity, and help prevent many diseases. As a result of poor sexual hygiene, sexually transmitted diseases spread and lead to deterioration in the reproductive health of the population. It is necessary to conduct systematic sanitary and educational work among adolescents on issues related to the beginning of sexual activity, the characteristics of sexual contacts, means of preventing sexually transmitted diseases and contraception, etc.

Maintaining positive emotions. A state that arises as a result of satisfying a certain need and causes a feeling of elation and warmth. Thoughts about what you want make you happy and satisfied, and such feelings increase immunity. At the same time, negative emotions and constant stress hurt the human body, causing fatigue, drowsiness, apathy, and emotional burnout.

Continuous intellectual development is the key to a healthy lifestyle for every person and should continue at any age. The development of intellectual abilities begins in early childhood and never ends. However, performing monotonous work leads to a cessation of intellectual development.

Systematic medical examinations are one of the most important forms of disease prevention. During the examinations, it is possible to detect or prevent the occurrence of a pathological condition, as well as to improve or maintain the general condition of the human body in the presence of chronic diseases. All categories of the population, without exception, need to exercise systematic self-monitoring of their health.

The results of the analysis of the peculiarities of students' compliance with the basic rules of a healthy lifestyle are presented in Table 1. Within the framework of the principle of quitting bad habits, we have studied such components as tobacco smoking among students, consumption of alcoholic beverages and drugs. It was found that the number of students who smoke in the 4th instructional year is significantly ($p<0.05$) higher than in the 1st year:

Table 1. Peculiarities of students' compliance with the rules of a healthy lifestyle, %

Basic rules of a healthy lifestyle	Components of healthy lifestyle rules	Students' answers	1st instructional year (n = 123)		4th instructional year (n = 96)		Reliability of the difference (T; p)	
			Males (n = 66)	Females (n = 57)	Males (n = 55)	Females (n = 41)	Males	Females
Quitting bad habits	Smoking	Yes	59.1	43.8	76.3	68.3	6.76; <0.05	12.18; <0.05
		No	40.9	56.2	23.7	31.7		
	Drinking alcoholic beverages	Yes	31.8	28.1	69.1	58.5	27.82; <0.05	18.82; <0.05
		No	68.2	71.9	30.9	41.5		
	Drug abuse	Yes	0	0	0	0	0; >0.05	0; >0.05
		No	100	100	100	100		
Daily routine	Adherence to a rational routine	Yes	53.1	52.6	43.6	43.9	1.80; >0.05	1.51; >0.05
		No	46.9	47.4	56.4	56.1		
Motor activity	Performing morning exercises	Yes	21.2	15.8	16.4	9.8	0.75; >0.05	1.62; >0.05
		No	78.8	84.2	83.6	90.2		
	Visiting sports clubs	Yes	28.8	33.3	25.4	29.3	0.29; >0.05	0.37; >0.05
		No	71.2	66.7	74.6	70.7		
Sensible nutrition	3-4 times a day in compliance with the regimen	Yes	18.2	19.3	14.5	12.2	0.50; >0.05	1.89; >0.05
		No	81.8	80.7	85.5	87.8		
Regular medical examinations	Compliance with health monitoring	Yes	9.1	29.8	10.9	31.7	0.18; >0.05	0.08; >0.05
		No	90.9	70.2	89.1	68.3		

Legend: T – the value of χ^2 – criterion; $T_{critical}$ – 6.0; p – significance of the difference between the indicators of students of the 1st and the 4th years of study

among men – by 17.2%, among women – by 24.5%. This negative trend can be explained by the lack of attention in higher educational institutions to the formation of students' necessary knowledge about a healthy lifestyle and the observance of the basic rules of a healthy lifestyle, and the lack of motivation among students to stop this addiction during their studies. A similar trend is observed among students who consume alcohol. The number of such students in the 4th instructional year is significantly ($p<0.05$) higher compared to the 1st year, by 37.3% among men and 30.4% among women. Notably, there is a large percentage of smoking students, both men and women, in the 4th instructional year (76.3% and 68.3%, respectively) and students who drink alcohol (63.1% and 58.5%, respectively). At the same time, it should be noted that not a single student reported taking drugs.

With regard to observance of a rational daily routine, more than half of the surveyed students have a rational daily action plan and adhere to it (53.1% of men and 52.6% of women) in the 1st instructional year. The number of such students is lower in the 4th instructional year compared to the 1st year, by 9.5% among men and 8.7% among women, but no significant difference was found between the 1st and 4th instructional year indicators ($p<0.05$). Motor activity is an extremely important principle of a healthy lifestyle. However, the research found that only 21.2% of 1st-year male and 15.8% of female students regularly perform morning physical exercises, 28.8% of 1st-year male and 33.3% of female students attend sports clubs during extracurricular hours. These indicators tend to deteriorate in the 4th instructional year ($p<0.05$), which indicates a lack of motivation among students to follow the rules of a healthy lifestyle in the process of studying at a higher educational institution. In addition, it was found that less than 20% of students, both in the 1st instructional year (18.2% of men and 19.3% of women) and in the 4th year (14.5% of men and 12.2% of women), adhere to sensible nutrition. That is, the vast majority of students have an irrational, inadequate, and mostly monotonous diet. It was found that only 9.1% of men in the 1st instructional year and 10.9% in the 4th year attend regular medical examinations. Among women, this indicator is much better, but not high enough – 29.8% in the 1st instructional year and 31.7% in the 4th instructional year. There was no significant difference between the indicators of the 1st-year and 4th-year students ($p<0.05$). Thus, the vast majority of students do not adhere to the rules of a healthy lifestyle during their studies, which can negatively affect the effectiveness of their educational and future professional activities, as well as their health.

DISCUSSION

The human right to preserve and promote one's health is regulated by the Charter of Human Rights and a number of other international regulations. Ukrainian healthcare legislation covers the basic rules of healthcare, the rights, and obligations of citizens, the basics of healthcare organization, etc. The foundations of the health care system paradigm aimed at implementing a healthy lifestyle at the level of the WHO member states were first legally enshrined during the World Health Assembly (1977) in the strategic concept of health for all [11]. According to this paradigm, the WHO's priority is to promote a healthy lifestyle. To this end, it is proposed to mobilize public opinion and the media, as well as to direct education to study the issues of preserving the health of people, especially young people [12].

According to scientists [13, 14], the concept of "health" is characterized by the following components: physical – characterized by the absence of acute and chronic diseases and birth defects; mental – an adequate response to psycho-emotional stimuli, the absence of apathetic thoughts; spiritual – an inherent sense of justice, love, forgiveness, and responsibility; social – the presence of a certain status in society, which positively affects self-esteem; intellectual – the ability to obtain certain knowledge and use it in certain situations. To the list above, scientists [15, 16] add the emotional and financial components of health, which, according to scientists, reduce stress and improve the mental and physical well-being of the population. Reuter P et al. and several other scientists [17, 18] identify the following signs of health: normal functioning of organs; absence of acute, chronic, or genetic diseases; the ability to perform basic functions independently; preservation of the body's equilibrium state under the influence of certain factors; the ability of the body to adapt to the environment; complete physical, mental, spiritual, intellectual and social well-being.

Li Y et al. [19] identify levels of a healthy lifestyle and characterize them: individual – a person's activity, own daily routine, the balance between work and leisure, the ability to use personal resources, adequate nutrition, proper sexual behavior, family and social relations; group – the ability to interact, communicate and set goals that are worth achieving with benefit; national – exterior policy is aimed at the conscious support of personal health and the health of the nation.

According to Thwaite T et al. and several other scientists [20, 21, 22], the implementation of healthy lifestyle rules depends on socio-economic opportunities and patterns of human behavior, including motivation. Motivation for a healthy lifestyle is a system of value orientations, and internal motivations to preserve, restore and promote one's health. Motives are divided into internal (motives for which a person performs a certain action) and external (motives encouraged by society). The involvement of student youth in a healthy lifestyle should begin with the formation of their health motivation. Caring for and promoting health are the main value motives that shape, regulate, and control lifestyle [23].

CONCLUSIONS

The basic rules of a healthy lifestyle were characterized. It was found that a healthy lifestyle as a complex, multifaceted system is based on the following rules: quitting bad habits, optimal work and rest regimen (daily routine), sleep hygiene, personal hygiene, motor activity, hardening, proper nutrition, psychophysical self-regulation of the body (the ability to

withstand stress), sexual culture, productive life (satisfaction from the day, positive emotions, intellectual development), and systematic medical examinations.

The peculiarities of compliance with the basic rules of a healthy lifestyle among modern student youth were studied. It was found that more than 70% of students, regardless of gender, smoke, and more than 60% drink alcohol. Herewith, the difference between the 4th- and 1st-year students is significant ($p<0.05$). Less than half of the surveyed students adhere to a rational daily routine; less than 20% of students do morning physical exercises; less than 30% of students attend sports clubs during their extracurricular hours; less than 20% of students follow sensible nutrition; about 10% of men and about 30% of women undergo regular medical examinations. All of these indicators tend to deteriorate in the 4th instructional year, which indicates that higher educational institutions do not pay enough attention to the development of students' necessary knowledge, skills, and abilities concerning a healthy lifestyle, and lack of motivation among students to follow the rules of a healthy lifestyle in the process of studying at a higher educational institution.

Thus, the vast majority of students do not follow the rules of a healthy lifestyle during their studies, which can negatively affect the effectiveness of their educational and future professional activities, as well as their health.

Prospects for further research aim to study the peculiarities of compliance with the basic rules of a healthy lifestyle among older people.

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ORCID AND CONTRIBUTIONSHIP*
Natalia A. Lyakhova: 0000-0003-0503-9935[A]
Nataliia A. Dakal: 0000-0002-7030-5112[B]
Tetiana V. Napalkova: 0000-0002-5928-6117[D]
Larysa V. Anikeienko: 0000-0002-1781-3353[B]
Viktor P. Bilokon: 0000-0003-4138-8454[E]
Serhii M. Soha: 0000-0003-4599-2456[C]
Volodymyr E. Dobrovolskyi: 0000-0001-9598-5153[F]

ADDRESS FOR CORRESPONDENCE
Natalia A. Lyakhova
Poltava State Medical University
23 Shevchenko St., 36000 Poltava, Ukraine
e-mail: natanew2017@ukr.net

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ASSESSMENT OF MENTAL HEALTH PROBLEMS CAUSED BY THE WAR THROUGH THE EYES OF STUDENTS: PREREQUISITES FOR REHABILITATION MEASURES

Natalia O. Rynhach[1], Lyubov Y. Vlasyk[2], Tetiana L. Kolodnitska[2]

[1]PTOUKHA INSTITUTE FOR DEMOGRAPHY AND SOCIAL STUDIES OF THE NAS OF UKRAINE, KYIV, UKRAINE

[2]BUCOVINIAN STATE MEDICAL UNIVERSITY, CHERNIVTSI, UKRAINE

ABSTRACT

Aim: To identify the leading factors of mental health problems by establishing interconnections them with other challenges of full-scale war.

Materials and Methods: Sociological and statistical methods of descriptive statistics, the method of pairwise correlation of psychological problems with other challenges with disaggregation by gender, the logistic regression analysis for factors that were statistically significantly related to mental health problems (95% CI, $p<0.05$) were used.

Results: Since the beginning of the war respondents identified medical problems as the most important challenge (83.6%), which were combined with forced change of residence and restrictions on movement and communication (20.7%), financial problems (8.0%) and restrictions on non-medical services (1.1%). Statistical analysis revealed a weak direct correlation between male' mental health problems with age (20 and older) (r=0.225), restrictions on travelling abroad (r=0.221) and restrictions on habitual communication (r=0.215). Financial (r=0.190) and psychological (r=0.252) problems in relatives were the leading factors in the development of psychological disorders. In case of female, the most important factors in the occurrence of psychological problems were restrictions on usual communications (r=0.138), financial problems (r=0.104), illness (r=0.121), volunteering before the full-scale invasion (r=0.105), hearing about deaths (r=0.143) and mental health of loved ones (r=0.435).

Conclusions: Psychological problems among students had great significance (77.4%). The psychological state is most affected by the problems of loved ones, and this was a two-way connection. As part of rehabilitation measures, we anticipate an increasing role for primary health care and mental health promotion.

KEY WORDS: mental health, war, Ukraine, students, rehabilitation

INTRODUCTION

The war in Ukraine has triggered the most critical international geopolitical crisis with heavy human losses, including civilian casualties and mass migration [1]. From the very first days, the invasion of Russian troops with full-scale military operations in a large part of Ukraine's territory had a negative impact on the physical and mental health of all segments of the population. In the short term, treatment of chronic diseases and preventive health services, such as diabetes, heart disease, or cancer screening, were left without proper attention. Long-term consequences, such as depression and post-traumatic stress disorder, will affect future generations, especially with mental health conditions already exacerbated by the COVID-19 pandemic [2-4]. Previous studies have confirmed that armed conflict poses a huge burden on public health. Citizens of Ukraine are exposed to the threats on their lives on a daily basis, including shelling [5]. It is believed that the equivalent of studying reports on injuries and deaths as a result of military operations is to consider the impact of these events on mental health [6]. A number of studies on military conflicts have been limited to post-event surveys of veterans; studies have not examined mental health in real time during war. No any "special military operation" in the modern world has ever been accompanied by so many civilian casualties [7]. Surveys of Ukrainian citizens abroad, including university students, have revealed high levels of anxiety and depression [8, 9]. Surveys by an independent analytical center Cedos documented experiences and feelings of Ukrainian civilians of all ages in the first days of the full-scale invasion [10] and the dynamics of changes in emotional states during the first year of the war [11]. The need for further research is noted, including in certain socio-demographic groups. If it is impossible to fully accumulate statistical and epidemiological data during the war, it is sociological surveys that provide information about certain

changes in life, including in the field of public health. The choice of students for the online survey was made due to their high level of digital literacy and social activity. In addition, during crisis situations, the mental health of adolescents and young adults is at high risk [9, 12].

AIM

To find out the opinion of Ukrainian students about the importance of health-related problems in general and mental health in particular that have arisen since the beginning of the full-scale war. Identify the leading factors of mental health problems by establishing interconnections them with other challenges of full-scale war faced by students in order to develop long-term rehabilitation measures.

MATERIALS AND METHODS

The materials that were used are from an online survey of young people studying at higher education institutions in different regions of Ukraine (523 respondents (130 male and 393 female) from 16 educational institutions in different regions of Ukraine, except the South). The cross-sectional study was conducted by the Ptukha Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine to examine the impact of the Russian-Ukrainian war on the lives and health of students in May 2022 (fill out the Google form). The specially designed questionnaire included questions about the most important problems that students have faced since 02/24/2022. The block of questions related to health or medical care (hereinafter referred to as medical problems) included: injuries as a result of hostilities (wounds, traumas, burns, contusions, etc.); development (exacerbation) of diseases; restrictions on access to medical services; lack of medicines and equipment; psychological problems (mood swings, stress, depression). Students were allowed to choose several answers, and open-ended questions were also offered. Informed consent was obtained from all online survey respondents. This study was compliant with regulations Declaration of Helsinki of the World Medical Association.

Sociological and statistical methods of analysis using PIVOT and SPSS software were applied, in particular, the method of pairwise correlation of existing psychological problems with other life circumstances and challenges of war faced by respondents and their loved ones separately for male and female. The logistic regression analysis for factors that were statistically significantly associated with mental health problems (95% CI, $p<0.05$) to build a regression equation with the determination of the probability of the expected event. To compare the frequency of individual responses among male and female, the Student's t-test was used, significance was set at $p<0.05$.

RESULTS

The respondents were asked to choose from a list of 12 problems that they personally or their relatives have experienced as a result of Russia's full-scale invasion and the outbreak of hostilities in Ukraine, and to select those that they would consider the most important. An analysis of the responses showed that 83.6% of respondents identified medical problems as the most important. Medical problems were also combined with forced change of residence and restrictions on movement and communications (20.7% of all respondents), financial problems (8.0%) and restrictions on non-medical services (1.1%). Most often, a combination of three (30.4%) or four different problems were chosen (11.3%). Psychological problems were rated as the most important for themselves and their loved ones by almost the same proportion of respondents. Instead, respondents faced restrictions on movement within the country more often than their loved ones (37.7% vs. 28.7%), ($p<0.01$). All the problems rated as the most important were unevenly distributed, with a clear predominance of psychological problems (Fig. 1).

For male, the problems of the same direction were more typical in answers (30%) than female (17%), ($p<0.01$), (Fig. 2). Female (89.6%) were more concerned about medical problems than male (65.4%) ($p<0.01$).

The importance of psychological problems (mood swings, stress, depression) for students during the war increased compared to those during the COVID-19 pandemic (77.4% vs. 55.1%), ($p<0.001$). Female were more likely to report having psychological problems than male (85.2% vs. 53.8%), ($p<0.001$).

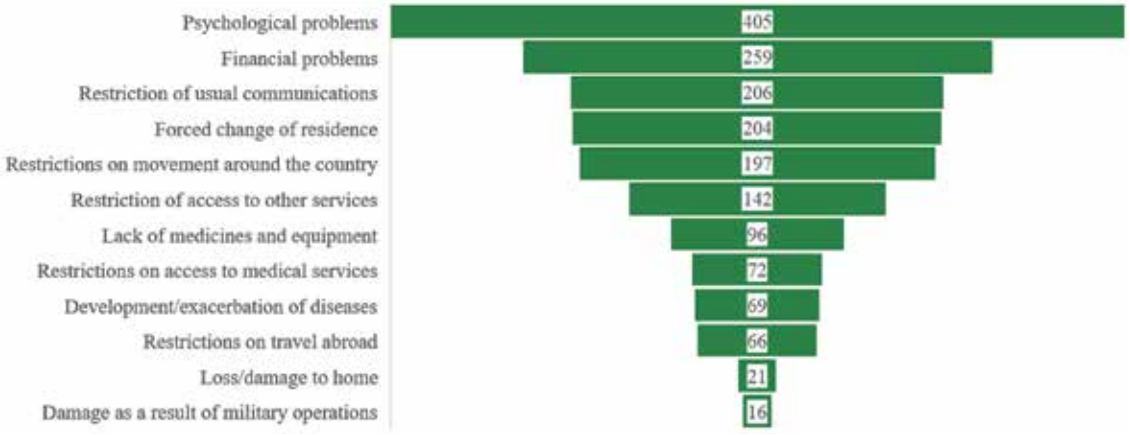

Fig. 1. Distribution of the sum of all the most important problems mentioned by respondents that have arisen since 02/24/22, N

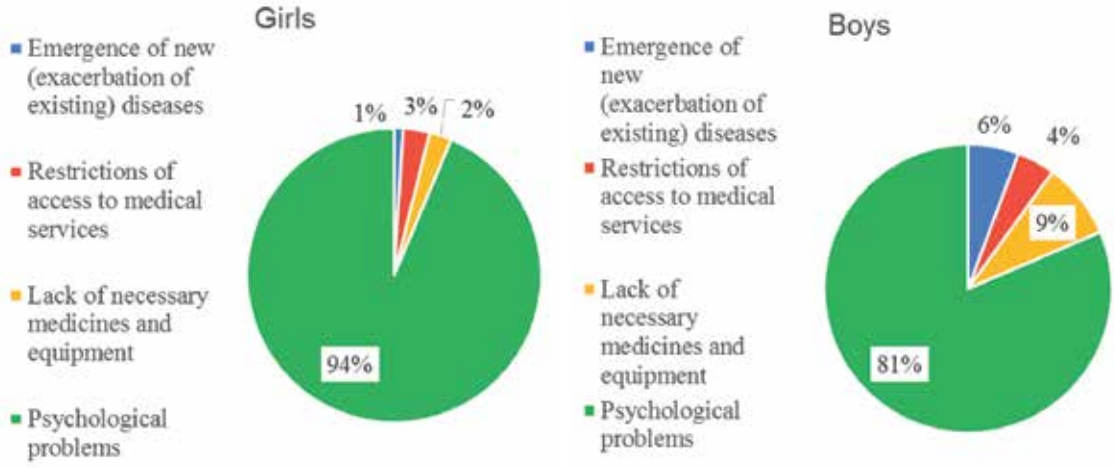

Fig. 2. Distribution of answers about the presence of medical problems by gender

Some respondents reported deaths in their immediate environment due to injuries caused by hostilities (2.5%) and, in the respondents' opinion, war-related (3.4%). Many more people confirmed the fact of such losses among friends/neighbors (32.3% and 11.9%). 30.0% and 21.6% of respondents respectively indicated that they had heard about such cases. The majority (more than 80%) of those who reported actual volunteer activities (both before and after the outbreak of war) simultaneously reported having psychological problems since 02/24/22.

The analysis revealed a weak correlation between male' mental health problems and age (20 and older) ($r=0.225$, $p<0.01$), restrictions on traveling abroad ($r=0.221$, $p<0.05$) and restrictions on habitual communication ($r=0.215$, $p<0.05$). The likelihood of psychological disorders increased in the presence of problems in relatives: financial ($r=0.190$, $p<0.05$) and psychological ($r=0.252$, $p<0.01$) with a 98% probability: $z_{male} = -9.009 + 1.539\ X_1 + 1.11\ X_2 + 1.271\ X_3 + 1.302\ X_4$; where X_1 – age; X_2 – restrictions on traveling abroad; X_3 – financial problems in relatives; X_4 – psychological problems in loved ones.

In the occurrence of psychological problems in female, the following were important: restrictions on usual communication ($r=0.138$, $p<0.01$), financial problems ($r=0.104$, $p<0.05$), the occurrence of new or exacerbation of chronic diseases ($r=0.121$, $p<0.05$), volunteering BEFORE the full-scale invasion ($r=0.105$, $p<0.05$), and problems of relatives: restriction of usual communication ($r=0.169$, $p<0.01$), their illness ($r=0.117$, $p<0.05$) and limited access to medical services ($r=0.109$, $p<0.05$). We found a weak direct correlation between female' mental health problems and hearing about deaths among neighbors/acquaintances ($r=0.143$, $p<0.01$) and a medium-strength direct correlation with the mental state of their relatives ($r=0.435$, $p<0.01$). The logistic regression analysis revealed that the latter two were the leading factors with a 99% probability of mental health problems: $z_{female} = -13.145 + 2.265\ X_1 + 1.093\ X_2$; where X_1 – mental health problems in loved ones; X_2 – hearing about deaths.

DISCUSSION

We recognize the methodological limitations of the survey. First, the different regions of the country were unevenly represented, with the smallest share of respondents from the Eastern and Southern regions, where the most active hostilities are taking place. Secondly, the ability to receive information about the survey and fill out the form offered by Google depended on the availability of a smartphone or PC, access to the Internet and, finally, electricity. Thirdly, the significant disproportion of respondents by gender (three quarters were female) was caused, in our opinion, not only by the fact there was a real predominance of female among those who received higher education in the pre-war period, but also to the involvement of some young men in military service. Nevertheless, we consider the results of the survey to be a valuable reflection of the assessments and perceptions of the importance of health (physical and mental) and medical care issues of a large group of students during a specific period of full-scale war. Through the eyes of the students, we were able to look into the problems of their families.

The burden of students' psychological problems will increase as the war continues and will accompany them for a long time after it ends. For example, a survey [11] showed that war-related experiences were more likely to bother respondents a year after the war began than at the beginning. The fact that almost two-thirds of students knew or heard about the deaths of loved ones/acquaintances from injuries as a result of hostilities, and more than every third knew about deaths from other causes directly/indirectly determined by the war, could not but affect their well-being. Most of the answers to the open-ended question in the same questionnaire about adding (if you wish) something about the changes that have taken place since 02/24/2022 relate to the psychological state and worries [13].

Since the beginning of the war, 32.5% of respondents said that they had started volunteering (8.6% reported this activity before 02/24/22). The survey "Youth Employment in the Context of War" (April 2022) showed that 15% of

respondents aged 20-35 reported that they had done volunteer work [14]. The National Institute of Mental Health (USA) defines self-care as "taking time to do things that help you live well and improve both your physical and mental health" [15]. In our opinion, caring for others and helping in difficult circumstances has become an activity that, among other things, has helped minimize one's own problems and maintain mental health.

The occurrence of mental health problems in female who volunteered before the war may indicate a special sensitivity to the problems of other people. This is confirmed by the correlation between female' mental health and hearing about deaths among neighbors/acquaintances. It is important that information about deaths not only in the family (3.4%), but also among friends/neighbors (21.6%) wounds the psyche of young people, especially female. "I have seen and heard a lot through social media," read the answers to open-ended questions, meaning that both fellow countrymen and fellow citizens can be considered close. The results resonate to the findings of a study in the Czech Republic, where a moderate correlation was found between the frequency of watching news about the war and the occurrence of feelings of anxiety among students (higher among female students) [8]. For male, one of the factors of experience was age (20 and older), which correlates with the higher risk of mental health disorders during the war in women and with reaching an older age [7].

The proportion of those who chose other problems from the medical block (injuries caused by hostilities, complications or development of new diseases, reduced access to necessary medical services, medicines and equipment) was lower. This can be explained by the young age when the body is not yet burdened by existing diseases, as well as by the fact that most people live in areas that are safer than the East and South of the country. The open-ended question "other" also mentioned the death of relatives, conflicts with parents, and gender discrimination (men), which could also determine psychological problems. One young man identified "not being able to see his beloved" as the most important problem that arose with the outbreak of war.

In 2023, the International Self-Care Day 2023 theme is "Resilience, adaptability, and thriving in adversity". One of the recommendations for preserving mental health not only for young people but also for people of any age is to combine conscious self-care with caring for others, including volunteering. Relaxation, grounding, breathing exercises, and yoga practices can also be used to minimize the burden of psychological problems, either individually or in groups, including online, which is effective for students with experience of the distance learning during the pandemic. As part of rehabilitation measures, we can already anticipate the growing role of primary care physicians as part of multilevel models of mental health care and preclinical prevention to maximize coverage of the civilian population. Important tasks include improving access to medical services, restoring adherence to treatment for patients with chronic diseases, training medical personnel and introducing educational technologies for the general population on mental health.

CONCLUSIONS

At the time of the study, in May 2022, a set of issues related to health in general and mental health in particular among Ukrainian students was of great importance (77.4%), which requires monitoring the situation in the dynamics and supporting activities to increase resilience and skills to overcome stress and manage their own psychological state, aimed at the target audience.

The leading factors of psychological disorders in male were age (20 and older) (r=0.225), restrictions on traveling abroad (r=0.221), financial (r=0.190) and psychological (r=0.252) problems in relatives. For female, the leading factors were information about deaths (r=0.143) and the psychological problems of loved ones (r=0.435).

In the context of war, the psychological state of students is most affected by the problems of family and relatives, and this is a two-way relationship. Establishing communication, free movement and security are essential for restoring the psychological health of families.

Within the framework of rehabilitation measures, the role of primary medical care is expected to grow in multi-level models of mental health care and preclinical prevention, with the appropriate training of medical workers and the introduction of educational technologies, including those aimed at the target audience (students, military personnel, internally displaced persons, etc.).

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ORCID AND CONTRIBUTIONSHIP*
Natalia O. Rynhach: 0000-0002-5916-3221[A-F]
Lyubov Y. Vlasyk: 0000-0002-9241-5152[C-E]
Tetiana L. Kolodnitska: 0000-0001-9907-5325[C]

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ADDRESS FOR CORRESPONDENCE
Natalia O. Rynhach
Ptoukha Institute for Demography and
Social Studies of the NAS of Ukraine
60 Taras Shevchenko Blvd., 01032 Kyiv, Ukraine
e-mail: n_ryngach@ukr.net

* Contribution: A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval.

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POSTISOMETRICAL RELAXATION HEMODYNAMIC EFFECTS IN PATIENTS WITH CERVICOCRANIALGIA AND VESTIBULAR DYSFUNCTION

Valeriy I. Kalashnikov[1], Rooslan S. Vastyanov[2], Olena A. Gozhenko[3], Tamara O. Andreeva[4], Olexandr M. Stoyanov[2], Hanna M. Chebotareva[5], Oksana O. Ostapenko[2]

[1]KHARKIV NATIONAL MEDICAL UNIVERSITY, KHARKIV, UKRAINE
[2]ODESA NATIONAL MEDICAL UNIVERSITY, ODESA, UKRAINE
[3]SE "UKRAINIAN RESEARCH INSTITUTE OF TRANSPORT MEDICINE" OF THE MINISTRY OF HEALTH OF UKRAINE, ODESA, UKRAINE
[4]P. MOHYLA BLACK SEA NATIONAL UNIVERSITY, MYKOLAIV, UKRAINE
[5]ODESA POLYTECHNIC NATIONAL UNIVERSITY, ODESA, UKRAINE

ABSTRACT

Aim: To investigate the hemodynamic indexes during the postisometric relaxation in patients with cervicocranial pain and vestibular dysfunction in patients with the cervical spine pathology.

Materials and Methods: The clinical examination included 85 patients of the young age with cervical spine instability. We use randomization into 41 patient with cervicogenic cranialgia and 44 patients with vestibular dysfunctions. Postizometric relaxation (PIR) sessions were included into patients treatment.

Results: Our results revealed increased time-averaged indexes of maximal blood flow velocity through vertebral and basilar arteries in patients with cervicogenic cranialgia. The same indexes were registered to be decreased in patients on the 2nd group. We found that hperreactivity to flexion-extension was determined in patients of both groups, and in patients of the 1st group to left-right rotation. After post-izometric relaxation sessions we registered a decrease in the headache intensity, frequency and duration in patients with cervicogenic cranialgia, and a decrease in dizziness intensity and ringing and tinnitus regression in patients with vestibular dysfunctions.

Conclusions: We found that hemodynamic changes in patients with cervicogenic cranialgia were manifested in the form of hyperperfusion through vertebral artery and basilar artery and a half-increase in reactivity indexes on rotatory tests. The hemodynamic effect of PIR was determined in the form of vertebral blood flow indexes through vertebral artery and basilar artery stabilization, as well as indexes of reactivity to rotatory tests normalization.

KEY WORDS: cervicogenic headache, vestibular dysfunction, postisometric relaxation, cerebral hemodynamics, reactivity index

INTRODUCTION

Prevention of the cerebral organic vascular changes development is the most urgent problem of modern medicine and neurology. It is necessary to determine the main risk factors for the possible cerebrovascular events active prevention at the stage of compensation of intracerebral pathological process. Cervical spine (CS) pathology is the most significant etiopathogenetic factor in these disorders development, and it has a significant prevalence recently, especially in young people [1-3].

A number of pathological mechanisms of vestibular dysfunctions (VD) development can be detected in conditions of cerebral chronic ischemia [4]. Their clinical manifestations in case of vascular dyshemia has direct correlation the degree of brain damage [5, 6]. Vestibular dysfunction is the most common syndrome in cerebral acute and chronic ischemia with predominant vertebral-basilar basin (VBB) lesion [6]. An important aspect of VD occurrence is a change in vegetative-vascular reactivity, which greatly complicates the diagnosis and differential diagnosis of this pathology [6].

Cervicogenic cranialgia (CCA) occurs with CS degenerative-dystrophic pathological changes (dystrophic processes in the discs, CS instability, unvertebral arthrosis, etc.) which leads to compression or irritation of sensitive nerve roots, sympathetic muscles of the neck and occipital region, which might result in the pain initiation [7].

The first three cervical sensory roots form close connections with the trigeminal nerve, forming the trigeminocervical system, and make the CCA pathophysiological background [7]. The pain in CS is caused by the excitation of nociceptors located within the vertebral column, muscles, tendons, roots, and vertebral arteries [8]. The most common place of CCA is the occipital region. Pain irradiation occurs more

often in the temporal, parietal and/or frontal area and homolateral eye socket. The pain is more often has dull of medium intensity, it has an attack-like character, lasts from several hours to several days [9].

The method of transcranial dopplerography (TCD) of the main vessels of the head for a long time was successfully used for the main arteries both extracranial and intracranial parts lesions diagnosis. This method results not only in spatial localization of the pathological process, but allows to obtain detailed information about the cerebral hemodynamic indicators ratio, especially, in patients with headache [10-12]. Methods of differentiated myofascial manual therapy and individual kinesiotherapy within the complex of medical and rehabilitative measures contribute to locomotor apparatus functional activity normalization and suppress degenerative processes [13,14]. The method of post-isometric relaxation (PIR) belongs to the varieties of manual therapy and is actively used in the vertebral pathology complex treatment, in particular, CCA [15]. We suppose promising to use TCD to control the CS pathology manual treatment efficacy.

AIM

The aim of the present work was to investigate the hemodynamic indexes during the post-isometric relaxation in patients with cervicocranial pain and vestibular dysfunction in patients with the cervical spine pathology.

MATERIALS AND METHODS

Our clinical investigation complies with the principles of Helsinki Declaration, the rules of Good Clinical Practice and the legal requirements established for this type of clinical studies. 85 patients (46 women, 39 men) of a young age (18-35 years) with CS degenerative changes and instability were investigated. All patients were randomized into two clinical groups according to dominant syndrome: the 1st group – 41 patients with CCA, the 2nd group – 44 patients with VD. The control group consisted of 25 practically healthy volunteers of the appropriate gender and age.

The intensity of pain syndromes was studied using a standard visual analog scale (VAS).

All patients underwent CS X-ray examination with functional loads. X-rays of the neck were performed on a digital radiographic and fluoroscopic system "OPERA T90x GMM" (Italy). X-rays were performed in standard modes, in direct and lateral projections with functional load (flexion-extension).

Cerebral arteries were examined via triplex mode using "Ultima-PA" ultrasound scanner (RADMIR, Ukraine). The time-averaged maximum blood flow velocity (TAMX) in the anterior (ACA), middle (MCA), posterior (PCA) cerebral arteries, vertebral (VA) and basilar (BA) arteries were studied. The BA reactivity indexes were also determined using the CS functional loads with the determination of reactivity indexes on left-right rotation (RIlr) and flexion-extension (RIfe).

Patients with established CS offered to undergo a course of PIR, consisting of ten sessions. The idea of this technique is short-term (5-10 s) isometric work of minimal intensity and passive stretching of the muscles in the next 5-10 s. These combinations are repeated 3-6 times, as a result of which persistent hypotonia occurs in the muscle and the original soreness disappears. The technique consists of two stages. At the first stage, the spasmed muscle is maximally stretched and fixed in this position. Next, the patient is asked to shorten the muscle, but at the same time the movement is prevented, that is, the muscle is shortened, but at the same time the movement does not occur (post-isometric work of the muscle). At the second stage, the patient relaxes and the muscle is further stretched to the maximum stretch. Then post-isometric contraction is performed again. This is repeated 3-4 times. Sessions were held daily for 10 days. These sessions duration was 25-30 min.

The data obtained were presented as mean (x) and the standard error of the mean (SE). One-way analysis of variance (ANOVA) followed by Neuman-Keuls post-hoc test was used to detect the significant differences between the investigated groups. The nonparametric Kruskal-Wallis test was used to detect the significant differences in case of raw absolute indexes using. $p<0.05$ was considered as statistically significant difference.

RESULTS

The presence of instability in one or more motor segments was determined in all patients. Signs of stair instability (SI) in the vertebral-motor segments (VMS) C_2-C_6 were detected in 17 (41.5%) patients of the 1st group and in 13 (29.5%) patients of the 2nd group. Isolated instability (II) in VMS C_2-C_3 was noted in 9 (21.9%) patients of the 1st group and in 7 (15.9%) patients of the 2nd group; in the VMS C_3-C_4 - in 14 (34.1%) patients of the 1st group and in 12 (27.3%) patients of the 2nd group; in VMS C_4-C_5 - in 2 (4.9%) patients of the 1st group and in 6 (13.6%) patients of the 2nd group; in VMS C_5-C_6 - in 1 (2.4%) patients of the 1st group and in 5 (11.4%) patients of the 2nd group.

33 (80.5%) patients with CCA revealed dull pain of medium or high intensity, in 25 (61.0%) patients pain mainly localized in the cervical-occipital region, in 12 patients (29.3 %) – in parietal-occipital region. More often pain registered monolaterally with an attack-like character (73.2%). Pain occurs more often after staying in an uncomfortable position, i.e., during sleep (34.1%), turning and/or tilting the head (29.3%), in some cases when combing hair, neck movements, may be accompanied by a feeling burning (17.1%), dizziness with nausea (24.4%), sensation of noise and ringing in the ears (17.1%), "flickering of flies" in front of the eyes (12.2%), decreased visual acuity and a feeling of veiling before the eyes (12.2%) as well as double vision (9.8%).

In patients with VD dizziness was non-systemic in 28 cases (63.6%), and in 16 cases (39.4%) it was systemic; caused by physical exertion (27.3%), head movements (34.1%), orthostatic changes (18.2%), fluctuations (usually an increase) in blood pressure (13.6%). Dizziness was also accompanied by noise in the head (38.6%), hearing loss (34.1%), autonomic lability (31.8%), orthostatic hypotension (18.2%).

The hemodynamic parameters in ACA and PCA in patients of both groups did not differ significantly from the control data. Blood flow indexes in MCA were moderately reduced, with an emphasis in patients with VD, which confirms the value of MCA hemodynamics as an indicator of cerebral vascular disorders. Blood circulation velocity in the group with CCA was significantly increased via VA (49.1±5.3 cm/s vs control 34.7±9.1 cm/s; p<0.05) and via BA (49.8±4.2 cm/s vs control 38.9±4.4 cm/s; p<0.05). In the 2nd group patients a moderate decrease in bloodflow indexes was observed in VA (30.6±5.8 cm/s vs control 34.7±9.1 cm/s; p>0.05) and BA (31.4±6.2 cm/s vs control 38.9±4.4 cm/s; p>0.05). These changes could be explained by the presence of a predominantly irritative variant of VBB dyscirculation in patients with CCA and the presence of predominantly compressive disorders in patients with VD (Table 1).

The patients of the 1st group showed significant hyperreactivity to left-right rotation (RIlr - 1.27±0.03 vs the control 1.18 ± 0.03; p<0.05) and flexion-extension (RIfe – 1.26±0.05 vs the control 1.16±0.04; p<0.05). A significant increase in flexion-extension reactivity was noted in patients of the 2nd group (RIlr - 1.29±0.06 vs the control 1.16±0.04; p<0.05). The index of reactivity to left-right rotation tests was slightly increased (RIlr - 1.22±0.05 vs the control 1.18±0.03; p>0.05; Table 2).

It should be concluded that cephalic syndrome occurrence in patients with CS instability is largely due to the pathological reaction of CS vessels to left-right turns of the head, while the VD occurrence is more related to CS flexion and extension.

Due to the fact that manipulative techniques are contraindicated in the case CS instability, the examined patients were offered to undergo a course of PIR. After

Table 1. TAMX indexes (sm/s) in brain arteries in patients with CCA and VD

Groups of patients	MCA	ACA	PCA	VA (V4)	BA
Group 1	57.2±8.4	54.3±7.3	40.8±4.3	49.1±5.3*	49.8±4.2*
Group 2	54.3±9.2	51.6±5.8	36.5±4.7	30.6±5.8	31.4±6.2
Control group	62.6±10.1	52.3±6.7	36.5±5.7	34.7±9.1	38.9±4.4*

*Notes: * – p<0.05 – significant differences in the studied parameters compared to those in the control group*

Table 2. Reactivity indexes on rotary tests in BA in patients with CCA and VD

Groups of patients	RIlr	RIfe
Group 1	1.27±0.03*	1.26±0.05*
Group 2	1.22±0.05	1.29±0.06*
Control group	1.18±0.03	1.16±0.04

*Notes: * – p<0.05 – significant differences in the studied parameters compared to those in the control group*

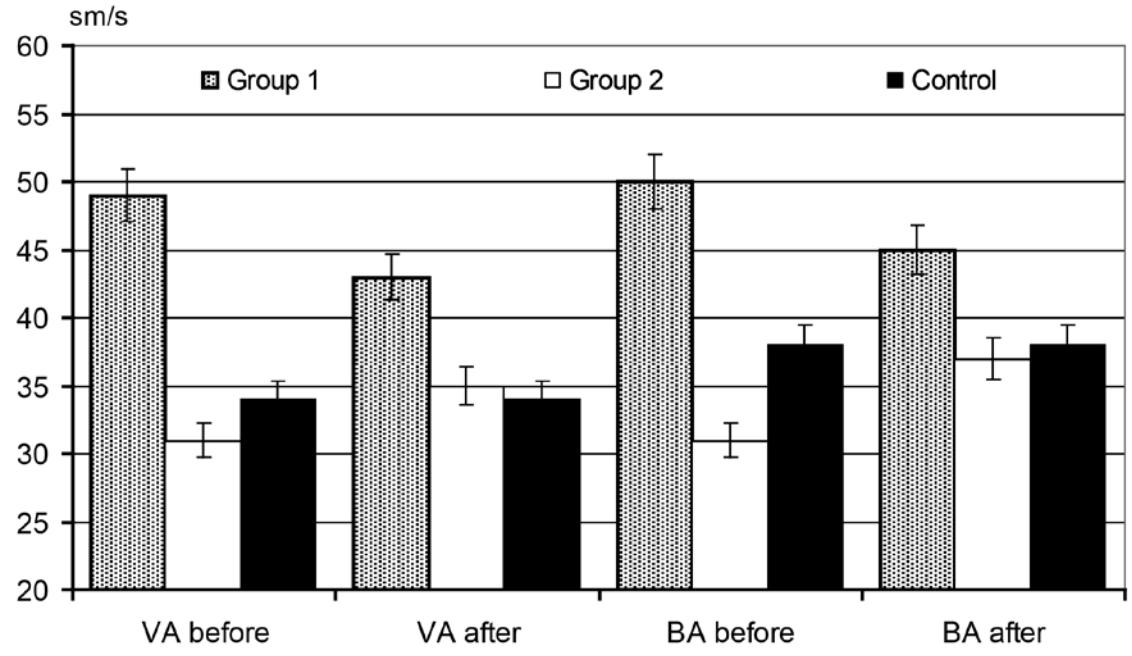

Fig. 1. Dynamic of TAMX indexes in VA and BA in patients with CCA and VD after the PIR administration

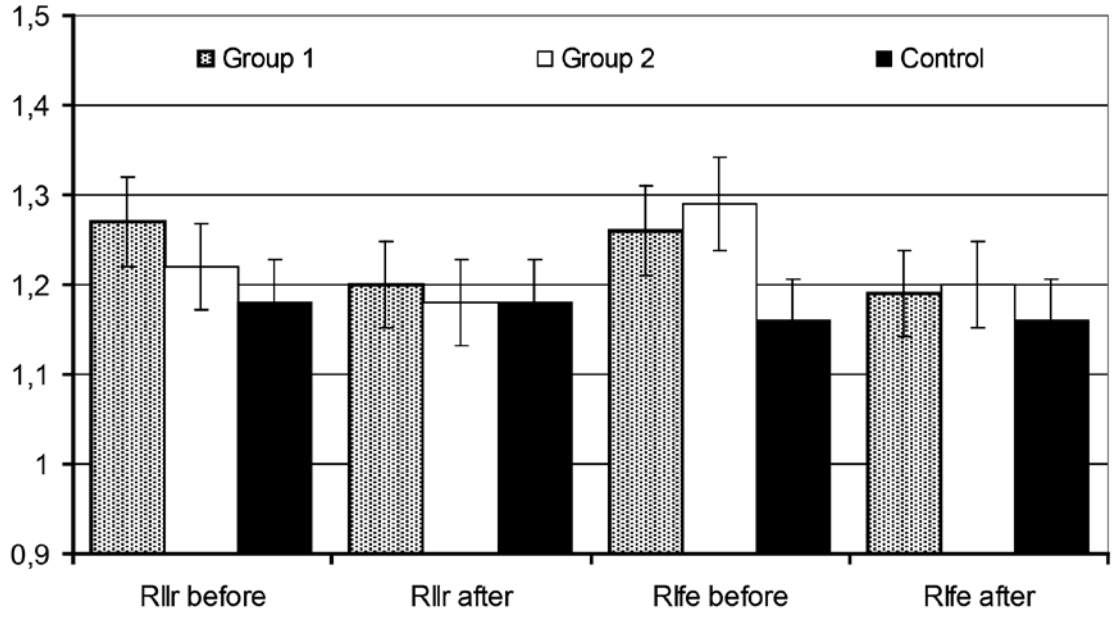

Fig. 2. Dynamic of RIIr and RIfe indexes in BA in patients with CCA and VD after the PIR administration

the post-isometric relaxation course, the patients were prescribed a set of self-relaxation exercises.

34 (82.9%) patients of the 1st group had a decrease of headache intensity according to the VAS scale, in 30 (73.2%) patients we registered a decrease in the frequency and duration of cephalic attacks, in 26 (63.4%) patients - partial regression of accompanying symptoms (dizziness, nausea, decreased visual acuity, etc.).

In the 2nd group we registered a significant decrease in dizziness intensity in 31 (70.5%) patients, regression of ringing and tinnitus in 18 (40.9%) patients, a decrease in autonomic lability symptoms in 14 (31.9 %) of patients. Almost all patients in both clinical groups noted working capacity, memory and quality of night sleep improvement.

The provided PIR session hemodynamic effect was observed in both clinical groups. In the 1st group there was a slight decrease in the initially elevated TAMX in VA (from 49.1±5.3 cm/s to 43.4±6.2 cm/s) and BA (from 49.8±4.2 cm/s to 44.8±5.9 cm/s). More significant positive dynamics was observed in the 2nd group where the hemodynamic indexes increased to the normal ones in VA and BA (Fig. 1).

A similar trend was observed for reactivity indexes on rotary tests. In both clinical groups one could register a decrease in the initially elevated RIIr and RIfe indexes after the PIR sessions. It should be noted that in the 2nd group patients RIIr index stabilized to normal values, other indexes in both groups after treatment were close to control ones (Fig. 2).

DISCUSSION

Therefore, the data obtained demonstrate vascular component importance in CCA and VD in patients with CS pathology pathogenesis. Certain hemodynamic signs characteristic for each clinical group were observed. CCA patients demonstrated patterns of hyperperfusion both in VA and BA together with hyperreactivity on functional tests with left-right rotation. We registered reduced perfusion in VA and BA in patients with VD as well as expressed hyperreactivity to all functional loads with hyperreactivity to flexion and extension tests prevalence. Theses irritative and compressive changes in observed patients confirms the concept concerning the different patterns of hemodynamic existence in persons with CS pathology [16].

The data obtained proved the positive impact of PIR method on the clinical condition of patients with CCA and VD with the CS degeneration and instability. As the result of the provided treatment, there was a decrease in the intensity and frequency of headache attacks in patients with CCA, a decrease in dizziness intensity and regression of ringing and tinnitus in patients with VD together with partial regression of accompanying symptoms in both clinical groups.

The positive impact of PIR on the cerebral hemodynamic resulted in changed blood flow velocity VA and BA indexes stabilization and reactivity indexes to CS rotatory functional loads normalization. Our results confirm the previously described clinical observations regarding the positive effect of cervicogenic headache [17, 18] and VD [19] manual treatment. Our research also confirm existing opinion concerning the PIR positive influence on VA blood circulation in patients with cervicogenic cranialgia [15]. It should be mentioned also that contrary to the above-mentioned authors we firstly investigated the positive impact of manual treatment on indexes of reactivity to rotational loads.

We supposed to be interesting and promising the further targeted research of the PIR method influence on the deep mechanisms of vascular autoregulation in patients with CS instability.

CONCLUSIONS

1. Hemodynamic changes in patients with CCA are manifested in the form of hyperperfusion through vertebral artery and basilar artery and a half-increase in reactivity indexes on rotatory tests.
2. Hypoperfusion through vertebral artery and basilar artery and rotatory tests hyperreactivity with an emphasis on flexion-extension were registered in patients with VD.
3. The PIR method resulted in the intensity and frequency of headache attacks decrease in patients with CCA, and in dizziness intensity decrease and ringing and tinnitus regression in patients with VD.
4. The hemodynamic effect of PIR was determined in the form of vertebral blood flow indexes through vertebral artery and basilar artery stabilization, as well as indexes of reactivity to rotatory tests normalization.

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ORCID AND CONTRIBUTIONSHIP*
Valeriy I. Kalashnikov: 0000-0002-7012-1698[A,C,D]
Rooslan S. Vastyanov: 0000-0001-8585-2517[E,F]
Olena A. Gozhenko: 0000-0002-4071-1304[A,B,D]
Tamara O. Andreeva : 0000-0002-4357-320X[A,C,D]
Oleksandr M. Stoyanov: 0000-0002-3375-0452[A,F]
Hanna M. Chebotareva: 0000-0002-0732-963X[B,E]
Oksana O. Ostapenko: 0009-0002-0277-7019[C,E]

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ADDRESS FOR CORRESPONDENCE
Valeriy I. Kalashnikov
Kharkiv National Medical University
58 Amosova St., 61176 Kharkiv, Ukraine
e-mail: dr.valkalash@gmail.com

* Contribution: A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval.

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REVIEW ARTICLE

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THE EFFECTIVENESS OF PHYSICAL MANEUVERS IN THE CONVERSION OF SUPRA-VENTRICULAR TACHYCARDIA ON THE EXAMPLE OF THE VALSALVA'S MANEUVER

Katarzyna Joanna Ślusarczyk[1], Jakub Mikołaj Kasperowicz[2], Dominik Maciej Gałuszka[2], Mateusz Wilk[3], Anita Kocięba-Łaciak[1], Paweł Blicharz[4]

[1]HEALTH SCIENCE INSTITUTE, CAVALRY WITOLD PILECKI STATE UNIVERSITY OF MAŁOPOLSKA IN OŚWIĘCIM, OŚWIĘCIM, POLAND
[2]EMERGENCY MEDICINE DEPARTMENT IN TARNÓW, EMERGENCY MEDICAL TEAM, TARNÓW, POLAND
[3]COLLEGIUM MEDICUM WSB UNIVERSITY DĄBROWA GÓRNICZA, POLAND
[4]E.SZCZEKLIK SPECIALIST HOSPITAL IN TARNÓW, RADIOLOGY LABORATORY, TARNÓW, POLAND

ABSTRACT

The Valsalva maneuver (VM) is one of the physical maneuvers used by medical personnel. In emergency medicine, it is known primarily for its use as a non-pharmacological method of restoring sinus rhythm possible to perform in almost every patient, and side effects are noticed incidentally. A distinction is made between the classic and the modified Valsalva tests. Multiple studies confirm its use and effectiveness in cases of supraventricular tachycardia episodes in hemodynamically stable patients.

The VM allows to determine heart failure by showing abnormal rise of blood pressure as a response to the Valsalva test and thus suggests impaired ventricular function. This maneuver lowers the preload and thus the end-diastolic volume, thereby enhancing some murmurs and weakening others. As a result of phase IV of VM, clinically significant bradycardia occurs, which is used for, at least temporary, termination of supraventricular tachycardia. Based on the available literature, the effectiveness of the modified Valsalva sample was almost twice as high as that of the classical method. However, both methods are effective in the conversion of supra-ventricular tachycardia. Its implementation is relatively simple and possible to perform for almost any patient, provided that he cooperates. As majority of patients using the services of sanatoriums are people burdened with numerous diseases, including cardiovascular diseases, some of them may present with supraventricular tachycardia. Hence, it is important to know simple, safe and non-pharmacological methods of stopping it, the most common of which is the Valsalva maneuver.

KEY WORDS: the Valsalva maneuver, tachycardia, cardiac patient, sanatorium, non-pharmacological method

INTRODUCTION

The Valsalva's maneuver is one of the physical maneuver involving forced exhalation with the glottis closed, leading to an increase in pressure inside the chest. As a consequence, this results in a reduction in the heart preload [1]. In emergency medicine, it is known primarily for its use as a non-pharmacological method of restoring sinus rhythm in an episode of supraventricular tachycardia. It was first described by the Italian physician Antoni Valsalve (1666–1723) as having significance in laryngology. Its aim was to unblock the Eustachian tube in patients with blocked outflow from the middle ear [2, 3]. This maneuver also found a number of other applications. It is part of a set of Ewing tests to assess autonomic cardiac neuropathy [4]. It allows to determine heart failure by showing over-exceeding of blood pressure as a response to the Valsalva test and suggests impaired ventricular function [5]. It was also found to be useful in distinguishing murmurs. This maneuver lowers the preload and thus the end-diastolic volume, thereby enhancing some murmurs and weakening others. The murmur associated with aortic stenosis decreases after Valsalva's maneuver. In contrast, the murmur associated with hypertrophic cardiomyopathy intensifies after its execution. This maneuver also occurs during physiological activities. This takes place when performing static efforts, among others during lifting significant weights, labor pressure, defecation or blowing into wind instruments [2]. As majority of patients using the services of sanatoriums are people burdened with numerous diseases, including cardiovascular diseases, some of them may present with supraventricular tachycardia. Hence, it is important to know simple, safe and non-pharmacological methods of stopping it, the most common of which is the Valsalva maneuver.

REVIEW AND DISCUSSION

PHYSIOLOGY OF THE VALSALVA MANEUVER

The Valsalva test physiologically consists of 4 phases. If the test is preceded by a deep breath, it is considered phase 0. It lowers the pressure inside the chest and increases

the flow of venous blood to it. As a result, blood pressure drops, causing a reflex from the baroreceptors resulting in tachycardia and peripheral vasoconstriction [6]. In phase I, the patient performs a push with the glottis closed (or tries to push out the syringe plunger) leading to an increase in chest pressure to a level of about 40 mm Hg. Along with the pressure in the chest, the pressure in the abdomen also increases, increasing the pressure on all vessels in these two cavities, especially on the superior and lower vena cavas, which reduces the inflow of venous blood to the chest [7]. Pressure on the aorta causes blood transfer to the peripheral arteries, intensifying the increase in blood pressure. At the same time, both systolic and diastolic pressure increases while maintaining constant pulse pressure [8]. In the heart, a decrease in preload is observed, compensated by a decrease in the afterload. The increase in blood pressure along with the increase in pressure in the right atrium causes, by reflex arcs from baroreceptors (especially carotid baroreceptors with a smaller role of aortic baroreceptors), a decrease in heart rate and slight vasodilation due to inhibition of sympathetic impulse. The result is a gradual decrease in blood pressure. In early phase II, during which the patient continues to push, elevated mediastinal and intra-abdominal pressure slows the return of venous blood to the heart [7]. The pressure in the peripheral venous system increases, and blood flow to the heart is only possible when the peripheral venous pressure exceeds the pressure in the veins. The decrease in venous return results in reduced pulmonary flow, resulting in reduced left atrium pressure and a reduction in end-diastolic, end-systolic, ejection volume and left ventricular stroke volume (LVSV) [9, 10]. The decrease in LVSV can reach up to 50%. The reduction in LVSV is thus partially compensated by a decrease in left ventricular upstream load [11]. Emptying the pulmonary circulation and heart cavities of blood may in some cases lead to a few seconds of cardiac arrest [12]. Diastolic pressure remains unchanged during this phase, while systolic pressure is significantly reduced, resulting in a decrease in pulse pressure. If the patient generates particularly high chest pressure, a significant reduction in left ventricular output is observed. As a result a drastic decrease in cerebral perfusion may occur. Clinical response would be fainting, especially if the patient maintains a sitting or standing position [13]. In late phase II, reduced pressure in the aorta and arterial vessels together with reduced pulse pressure (as detected by aortic and cervical baroreceptors) results in an increased sympathetic response resulting in peripheral vasoconstriction and sympathetic cardiac activation. This results mainly in a positive chronotropic and inotropic effect, the main effect of which is tachycardia [14]. The sympathetic reaction occurs with some delay, and is supported by the reaction of chemoreceptors to elevated pCO_2 and a slight decrease in pO_2. The chemoreceptor reaction itself is quite weak, and appears only a few seconds after the onset of hypoxia. In total, elevated heart rate with increased peripheral resistance makes it possible to maintain blood pressure within the normal range and even a slight increase in it compared to the baseline value [15]. In phase III, the patient stops pushing, which leads to a decrease in mediastinal pressure. Due to the decrease in resistance in the aorta, a large part of the cardiac output is used to fill the aorta with blood, which causes a short-term decrease in blood flow to the peripheral arteries and the ejection volume is reduced for a while due to a slight increase in the left ventricular afterload [16]. In connection with a decrease in pressure inside the chest, there is a sharp inflow of venous blood into the chest. All these factors lead to a drop in blood pressure [7]. Systolic and diastolic blood pressures decrease sharply. The same happens with the pulse pressure, which can lead to fainting in the patient [17, 18]. For a short time, the output of the right ventricle of the heart exceeds the output of the left ventricle of the heart. The decrease in blood pressure causes a further increase in sympathetic activity, leading to a further increase in vasoconstriction and thus peripheral resistance. In phase IV, the restoration of venous return improves the diastolic filling of the heart cavities, which causes an increase in left ventricular ejection volume and heart rate, which leads to an increase in blood pressure [11]. At the same time, peripheral resistance is still elevated, mainly due to sympathetic activity occurring in the earlier phases of the Valsalva maneuver. Elevated cardiac output in combination with peripheral vasoconstriction leads to a significant increase in blood pressure, up to about 40 mm Hg above the measurements before the test [19]. Systolic pressure increases more strongly than diastolic pressure, so the pulse pressure increases. For the aforementioned reasons, as well as due to the decrease in venous and intracranial pressure, the patient in this phase is most at risk of rupture of potential intracranial aneurysms [20]. The above changes cause a rapid response of the aortic and cervical baroreceptors, resulting in a significant slowdown of the heart rate, occurring mainly due to stimulation of the vagus nerve [21]. This mechanism is used in stopping supraventricular tachycardia. The cardiovascular system returns to the pre-Valsalva test values approximately 30 seconds after the end of the test [10].

VALSALVA MANEUVER TECHNIQUE

Valsalva's maneuver as a simple physical maneuver is actually possible to perform in almost every patient, and side effects are noted incidentally. In principle, it is not recommended to use it only in the case of current retinopathy or implanted intraocular lens. This is justified due to the occurring increase in intraocular and intra-abdominal pressure [22]. Caution should also be exercised in people with advanced coronary artery disease and a current valvular or congenital heart disease [23, 21]. The classic and modified Valsalva tests are widely distinguished. Each of them is a non-pharmacological method of restoring sinus rhythm by stimulating the vagus nerve. In view of various reports, clear results and effectiveness are still difficult to estimate. However, the use of the modified Valsalva test in a clinical setting allows for more accurate monitoring of the patient's response to the manoeuvrer used. This can significantly help to achieve the desired effect and limit the implementation of anti-arrhythmic pharmacotherapy [24]. The classic Valsalva test is performed in a sitting position in a patient connected to a device monitoring vital signs. It consists in performing with a clenched nose an extended

exhalation lasting 15 seconds under constant pressure. This maneuver is recommended to be repeated up to three attempts, and the intervals between them should not be less than 3 minutes. During each of them, the highest heart rate visible during the test and the lowest value obtained up to 60 seconds after the test should be recorded in the rhythm assessment [25]. In an outpatient setting, a disposable syringe or mouthpiece connected to a manometer can also be used during the Valsalva test, thus ensuring that a constant and desired expiratory pressure is maintained (≥ 40 mm Hg). The adequacy of the expiratory effort used during the test can be judged by the presence of subjective symptoms such as visible tension, redness and swelling of the jugular veins [21]. The modified Valsalva test differs substantially in that immediately after exhaling for 15 seconds in a semi-sitting position, a reposition should be performed on the back with passive elevation of the patient's lower limbs to an angle of 45 degrees, and then after 15 seconds return to the initial semi-sitting position for 30 seconds, measuring changes in heart rate in the same way as in the classic Valsalva test [26]. Based on observations, it can be concluded that the introduced modification is safe and shows higher efficacy in haemodynamically stable patients for the conversion of supra-ventricular tachycardia. This applies to both adult and co-existing pediatric patients [27].

EFFECTIVENESS OF THE VALSALVA MANEUVER

The effectiveness of the Valsalva test as a physical manoeuvrer in interrupting supra-ventricular tachycardia is the subject of many research trials. We focused on two scientific papers carried out in the recent past. One of them is a study performed by Ashraf et al., results of which were published in *Effectiveness of modified Valsalva maneuver by using wide bore syringe for emergency treatment of supra-ventricular tachycardias: Findings from Pakistan*. It compares the effectiveness of Valsalva tests according to classical and modified techniques. Patients were divided into two groups based on the type of Valsalva trial. The following factors were analyzed: systolic and diastolic pressure, saturation, heart rate before the maneuver, heart rate after the maneuver, prior diagnosis of supraventricular tachycardia, previous ablation, diabetes, hypertension, coronary artery disease, nicotinism, asthma / COPD and valvular heart diseases. No statistically significant differences were found between two groups. On the other hand, statistically significant differences between the groups where Valsalva test vs modified Valsalva test were performed, were found between: the fact of rhythm conversion (20% vs. 28%, p<0,001), the need for continued rescue treatment (96% vs. 42%, p<0,001) and the length of stay in the Emergency Department measured in hours (2.20±0.77 vs. 1.53±0.95, p<0,001). With regard to the above considerations, it should be observed in the current paper that the modified Valsalva test is more than twice as effective in converting supraventricular tachycardia as its classical variant, and that both are effective in interrupting this arrhythmia [28]. In second study taken into consideration in this paper, the results of which were published under the title *Postural modification to the standard Valsalva manoeuvre for emergency treatment of supra-ventricular tachycardias (REVERT): a randomised controlled trial* the authors of Appelboam et al. created two study groups of 214 participants each. One of the groups, in the case of supraventricular tachycardia, was subjected to the classic Valsalva test, and the other to its modified variant. There were no statistically significant differences between the compared groups that could affect the difference in response to physical maneuvers interrupting tachycardia in the same way as in the previously presented study. It is worth mentioning that physical tests in the analyzed cases were carried out by a total of 164 clinicians. This gives grounds to consider the maneuver as universal and effective to perform regardless of the experience of the person undertaking the instruction of its performance to the patient. After performing the manoeuver for up to 1 minute, tachycardia interruption was achieved in the case of 43% of subjects in the group where the modified Valsalva test was used, compared with the 17% effectiveness of the classical Valsalva test in taking into account the first manoeuvrer execution. This is another study where the effectiveness of the modified Valsalva test was observed almost twice as high as the classical method [26].

CONCLUSIONS

The Valsalva maneuver is a safe and universal physical maneuver. Studies confirm its use in episodes of supraventricular tachycardia in hemodynamically stable patients. Its implementation is relatively simple and possible to perform for almost any patient, provided that he cooperates. It is recommended to make up to 3 attempts before implementing pharmacological treatment. On the basis of the analyzed scientific studies, the superiority of the modified Valsalva sample over its classic version was demonstrated. Modified Valsalva maneuver was observed to be twice as efficient in restoring sinus rhythm as classic Valsalva Maneuver. In addition, it was pointed out that in the case of a modified maneuver, patients less often require further emergency treatment, thus the time of stay in the hospital or Emergency Department is shorter.

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ORCID AND CONTRIBUTIONSHIP*

Katarzyna Joanna Ślusarczyk: 0009-0003-7313-7403[D,E,F]
Jakub Mikołaj Kasperowicz: 0009-0008-9417-8163[D,E,F]
Dominik Maciej Gałuszka: 0000-0001-8797-4307[B,E,F]
Mateusz Wilk: 0000-0002-2561-7774[B,E,F]
Anita Kocięba – Łaciak: 0000-0001-9703-6453[E,F]
Paweł Blicharz: 0000-0002-6277-551X[A,E,F]

ADDRESS FOR CORRESPONDENCE

Katarzyna Joanna Ślusarczyk
Health Science Institute,
Cavalry Witold Pilecki State University
of Małopolska in Oświęcim
8 Kolbego St., 32-600, Oświęcim, Poland
e-mail: fkatarzyna.sl@gmail.com

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REVIEW ARTICLE

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APPLICATION OF BALNEOLOGICAL TREATMENT IN THE TREATMENT OF OBESITY IN CHILDREN

Katarzyna Placek[1], Bartosz Aniśko[2], Małgorzata Wójcik[2]

[1]DEPARTMENT AND CLINIC OF OBSTETRICS, WOMEN'S DISEASES AND ONCOLOGICAL GYNECOLOGY, COLLEGIUM MEDICUM IN BYDGOSZCZ, NICOLAUS COPERNICUS UNIVERSITY, TORUN, POLAND

[2]DEPARTMENT OF PHYSIOTHERAPY, FACULTY OF PHYSICAL CULTURE IN GORZÓW WIELKOPOLSKI, POZNAŃ UNIVERSITY OF PHYSICAL EDUCATION, POZNAŃ, POLAND

ABSTRACT

Aim: The purpose of this paper is to present the application of balneoclimatology in the treatment of obesity in children.

Materials and Methods: The literature presenting the application of balneoclimatology in the treatment of obesity in children is reviewed.

Conclusion: Balneological treatment in children seems little appreciated and described in the literature of the subject by research publications.

KEY WORDS: children, balneoclimatology, obesity

INTRODUCTION

According to the WHO (World Health Organization), obesity is a chronic disease of multifactorial etiology characterized by an increase in body fat mass of more than 25% of the total body (in men and 30% in women). The WHO has recognized obesity as a disease, and despite the introduction of a number of national and international preventive programs, the development of obesity has not been halted, and there is a steady dynamic growth of obesity. Worldwide, statistics show that more than 1,000,000 people are overweight and obese [1]. The activity level of children and others is very low, but varies from country to country and country to country [2].

In children, obesity is associated with lack of exercise and lack of regularity in physical activity [3]. External environmental factors include excessive food intake and inadequate diet composition and irregular meal intake, insufficient energy expenditure, stressful situations, inappropriate eating habits and physical activity, psychological and socioeconomic factors [4]. Genetic factors are assumed to be responsible for about 40% of obesity. There is no single gene responsible for obesity, there are usually multigene disorders, not yet fully understood. It is believed that eating habits can be inherited, resulting in the consumption of more energy. The finding of a family history of obesity is not enough to confirm the genetic nature of obesity. This is because family members are linked not only by genotype, but also by diet, socio-cultural environment, and lifestyle [5].

Obesity causes severe metabolic diseases and disorders. Obesity is accompanied by type 2 diabetes, hypertension, insulin resistance, lipid disorders, heart disease, depression and others. Among the factors leading to obesity, we can mention internal factors such as endocrine disorders involving the pituitary, adrenal hypothalamus and thyroid gland, disorders of the vegetative system involving excessive activity of the parasympathetic system, genetic disorders [6, 7].

The development of obesity in the first year of a child's life is particularly unfavorable. Parents' nutrition affects the development of obesity in their offspring. During the child's development period, fat cells multiply rapidly. A large number of these cells formed in childhood remain throughout a person's life.

Observations show that as many as 90% of obese children remain obese in adulthood, so only 10% attain a normal body weight [8, 9].

The main treatment methods are: dietary treatment including the key restriction of consumption of processed foods and sugar [10-13], health education [14], treatment with physical exercise [15,16], learning to change habits including sleep hygiene and activity [17-20], psychotherapy with active involvement of family members [21], and pharmacological treatment [22].

The choice of treatment method depends on: the degree and type of obesity, comorbidities, age and the degree of success of previous therapies. The choice of the appropriate method should always be fully accepted by the patient.

Children treated for obesity should always be treated individually and work in holistic teams. [23, 24]. Along with diet, exercise is the most important element in the treatment of obesity and comorbidities [25, 26].

Treatment of obesity in children at the balneological is accepted as the most favorable form of starting and conducting treatment, as it facilitates the change of environmental factors and is supported during school

education during the course of the resort [27, 28]. The advantage of spa treatment is the ability to provide health education and implement a proper lifestyle supported by balneological treatments while eliminating everyday factors that impede treatment. Children treated at the spa are mainly focused on themselves and their problem. The possibility of continuing school education additionally enables them to stay at the balneological for a longer period of time [29, 30].

Sanatorium treatment is tailored for children with multiple comorbidities, such as both T1 and T 2 diabetes [31]. Key in sanatorium treatment is the introduction of an individualized diet, which is easier to follow in a resort setting [32, 33].

AIM

The authors decided to present balneological treatment as an adjunctive and complementary management of obesity in children. A limitation of the presented topic is the insufficient number of scientific publications of a research nature.

MATERIALS AND METHODS

Two independent reviewers searched medical and public databases, e.g. PubMed, Google Scholar, using search terms and MeSH such as balneoclimatology (balneoklimatologia), balneology (balneologia), obesity (otyłość), children (dzieci). The inclusion criterion was to be an article published in a peer-reviewed journal with no restriction on the publication year range. There were no restrictions on the language of publication or the type of research. In this article, the authors consider aspects of the use of balneoclimatology for obesity in children. Failure to meet the inclusion criterion was treated as exclusion from the analysis. A review of journal databases was carried out between April and June 2023. Years of publication/books 2017-2023. These records were then assessed for compliance with the inclusion and exclusion criteria on the basis of abstract analysis. All the articles colleted were analysed in terms of the following parameters/content: what form/measure/modality of balneology was used in the treatment of obesity conditions, what conclusion was obtained as a result of the review. Due to the very small number of publications, books were also admitted to the review. Of the 265 references initially shortlisted for further analysis, 250 were rejected at this stage. The 15 remaining references were subjected to content analysis and a further 10 were rejected on the basis of further analysis due to duplication. The remaining 5 references were subjected to further analysis.

REVIEW AND DISCUSSION

Children's balneological treatment makes use of local natural resources such as mineral waters, peat and gases, which are used for baths, poultices, drinking treatments and inhalations. The use of climatotherapy resources is also important [34].

Balneological treatments used in the treatment of obesity in children are mainly: mineral water baths, fresh water pools, saline pool, hydrotherapy treatments and crenotherapy.

Brine baths with a concentration of usually 1.5%, water temperature 35-37°C, duration of treatment 5-10 minutes, 2-3 per week. Brine baths have a calming effect against pain increase metabolism and facilitate exercise. Properly applied, they have a wholesome effect. Massage and extensive kinesitherapy are also used supportively. A special place is occupied by kinesiotherapy baths in therapeutic waters. Children perform a special exercise program in the water that engages muscles while relieving pressure on joints. This treatment takes advantage of the therapeutic properties of mineral water and physical exercises.

In addition to balneological methods, physical therapy and light, electrotherapy, and magnetotherapy treatments are used [35-37]. A sauna can be used supportively in children over the age of three.

Climatotherapy is indicated for younger children who are still too young to undergo physical therapy treatments. According to the opinion of the Polish National Consultant in Balneology and Physical Medicine, medical ressort treatment for children under the age of three is not advisable, as their immature nervous and immune systems are unable to properly perceive and respond to stimuli provided during therapy [38].

Treatment of obesity in children differs significantly from that of adults. Due to their greater sensitivity to physical and psychological stimuli, different dosages and even partial withdrawal of therapy are recommended. In the case of children, the treatment performed may affect the whole body more often, and a small stimulus may cause an overreaction, so it is necessary to plan the child's therapy individually and extremely precisely during the stay at the sanatorium, taking into account the child's degree of morphological and functional development, general condition, nutritional status, type of disease and degree of progression. Balneological treatments from mineral waters applied in the form of an inhalation bath can be recommended at any age except during infancy. The exception is treatments from radon waters, which are definitely contraindicated in children of any age. Treatments should be performed every 2-3 days, strongly stimulating treatments should not be combined and the break between treatments in children should be 3h.

The range of physical therapy most commonly used is low-induction magnetotherapy, electrotherapy, laser biostimulation and polarized light, but physical therapy treatments are used less frequently in spa treatment than the other methods. The main purpose of using appropriately selected balneological and physical therapy treatments is to restore the regulatory capacity of the central and autonomic nervous systems.

Balneology methods mobilize immune mechanisms, stimulate the child's development and promote overall strengthening. Contraindications for balneological treatment of obesity include: significant mental retardation, Down syndrome with severe and profound underdevelopment, mental illness, comorbid epilepsy with consideration of clinical condition, heart defects, patients requiring individual care including the visually impaired deaf in the absence

of a caregiver, congenital defects significantly limiting physical functioning, skin lesions. For the female sex in gynaecological inflammatory conditions, balneoclimatology is more widely used [39].

CONCLUSIONS

Balneological treatment in children seems little appreciated and described in the literature of the subject by research publications.

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ORCID AND CONTRIBUTIONSHIP*
Katarzyna Placek: 0000-0003-3702-093X[A,B,D,E,F]
Bartosz Aniśko: 0000-0002-1688-7684[A,B,F]
Małgorzata Wójcik: 0000-0002-8313-8106[A,B,D,E,F]

CONFLICT OF INTEREST
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ADDRESS FOR CORRESPONDENCE
Katarzyna Placek
Clinic and Department of Obstetrics,
Women's Diseases and Oncological Gynecology,
Collegium Medicum in Bydgoszcz,
Nicolaus Copernicus University
University Hospital No. 2 Jana Bizielain
75 Ujejskiego St., 85-067 Bydgoszcz, Poland
e-mail:katarzyna.placek@interia.pl

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WIELKOPOLSKA PHYSIOTHERAPY CENTER

DEPARTMENT OF RHEUMATOLOGY REHABILITATION
AND INTERNAL MEDICINE
DEPARTMENT OF REHABILITATION AND PHYSIOTHERAPY

Zwierzchowskiego 31a
61-249 Poznan

509 828 727, 784 088 015
e-mail: spotkanieekspertow@gmail.com
www.spotkanieekspertow.pl

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Yours faithfully

Prof. dr hab. W. Samborski
Chairman of the Scientific Committee

Yours faithfully.

Dr M.W. Romanowski.
Chairman of the Scientific and Organizing Committee