

Rehabilitation treatment for patients with post-traumatic deformities of long bones of lower extremities in the long term after trauma

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Published online: March 31, 2023

(Accepted for publication March 15, 2023)

DOI:10.7752/jpes.2023.03091

Abstract:

Rehabilitation treatment after traumas of long bones of lower extremities is aimed, majorly, at recovery of support ability of a lower extremity, regeneration of full-blown participation of this extremity in walking and support of a vertical body posture. Traumas accompanied by emergence of deformities of long bones of lower extremities, cause overloads of individual muscles and ligaments, and also bio-mechanically connected groups of muscles and ligaments. **Purpose.** To examine recovery of support ability in patients with post-traumatic deformities of long bones of lower extremities, who went in for sports before traumas after rehabilitation treatment. **Research methods:** We conducted prospective research on 40 patients with post-traumatic deformities of long bones of lower extremities who went in for sports before traumas. In the research group there were 52.5 % of females (21 individuals) and 47.5 % of males (19 individuals). In the group of healthy participants there were 30.0 % of females (12 individuals) and 70.0 % of males (28 individuals). The indexes of pain were evaluated by VAS and the coefficient of load asymmetry – skewness (SL) before and after a rehabilitation course. Statistical processing of the research data was performed by means of a set of programs for general purposes STATISTICA. Every day all the patients were massaged according to our technology. Twice a day they did our proprietary therapeutic gymnastics. **Results.** Comparison of the groups allowed obtaining results, showing that, on the whole, the dynamics of both indexes (VAS and S) was higher in the group of females than in the group of males. The differences were statistically significant ($p < .01$; MWUT). The indexes of support ability provided by a right lower extremity (after treatment), a left lower extremity (after treatment) and S (after treatment) became identical to those of the healthy research participants (before treatment) in the females, however, that was not characteristic of the index S in the males. **Conclusions.** The suggested system of massage and selective therapeutic gymnastics, based on the hypothesis of anatomically and functionally connected muscles and ligaments, considerably reduces pain and recovers support ability of a body and lower extremities in individuals with consequences of traumas of long bones of lower extremities who went in for sports before traumas.

Key words: rehabilitation, deformities of long bones of lower extremities, recovery of support ability, massage, gymnastics.

Introduction

Rehabilitation treatment after traumas of long bones of lower extremities is majorly aimed at recovery of support ability of a lower extremity, regeneration of full-blown participation of this extremity in walking and supporting a vertical body posture. Traumas accompanied by emergence of deformities of long bones of lower extremities cause secondary changes in surrounding soft tissues. It is manifested in changes occurring in the distances between attachments of some muscles, that results in overloads for individual muscles and ligaments, and also bio-mechanically connected groups of muscles and ligaments with time (Mc Kay, 2016; Myers, 2020).

An increase in these distances is accompanied by strains of ligaments in these muscles, their micro-traumas and emergence of enthesopathy (Mc Kay, 2016; Korzh & Staude, 2021; Stecco, 2015; Kaichi Ozone, 2022). On the other hand, myofascial trigger points develop in muscles. These are knots located in the muscular layer (Bethers et al., 2021). These points manifest themselves in local or radiating pain occurring during palpation (Mayoral del Moral et al., 2018; San-Antolín et al., 2020). Trigger points are clinically divided into latent and active points (Jiménez-Sánchez, et al., (2021). Cygańska et al. (2022). Availability of latent trigger points in muscles can cause restriction of motions and reduce muscular strength (Walsh, 2019). Symptoms of active myofascial trigger points are intermittent pain, muscle weakness, reduction in muscle elasticity and referred pain (Ibrahim, (2021). Some authors believe that myofascial trigger points are a potential reason for musculoskeletal pain (Wilke, (2018). Myofascial pain is accompanied by muscle contracture and joint strains (Thummar, (2020),

Rajdeep Dasi, (2022). Therefore, rehabilitation of muscles of this segment is mainly aimed at regeneration of muscle balance, i.e. increasing tonus of overstretched muscles and stretching contracted muscles to improve their elasticity. Then it is necessary to stretch contracted muscles functionally connected with muscles of an injured segment by means of appropriately selected exercises (Myers, 2020). Restoration of muscle balance of the entire pelvic girdle and pelvis will allow restoring postural balance. Strengthening postural balance is a fundamental habit for everyday life of people (Izzo et.al.,2018). Recently, improvement of postural balance has become popular in standard athletic training programs (Izzo et.al.,2022).

Deformities of long bones of lower extremities affect frontal sagittal balance and causes functional overloads of muscles that maintain this balance and are functionally connected with each other (Mc Kay, 2016; Korzh & Staude, 2021; Panjabi, 2006).

If post-traumatic deformation causes “imbalance” of the pelvic bone or “twisted” pelvic bone, this deformity is eliminated by means of corrective heel cups, whose height is measured by the method suggested by R. Irwin (2018) and a complex of exercises restoring balance of muscles stabilizing pelvic bones and a vertical body posture (Irwin R.E., 2018). The next important direction of rehabilitation will be regeneration of muscle balance maintaining “sagittal” rhythm in walking (Don Tigny, 2005).

Purpose. To examine recovery of support ability in patients with post-traumatic deformities of long bones of lower extremities who went in for sports before traumas after the suggested rehabilitation therapy in the long term after traumas.

Material and methods

We conducted prospective research on 40 patients with post-traumatic deformities of long bones of lower extremities who went in for sports before traumas. More than 12 months had passed since the time of trauma in all the patients. The research group involved 52.5 % of females (21 individuals) and 47.5 % of males (19 individuals). The age of the women ranged from 27 to 73 years with the median of 45 years; the age of the men was 29-77 years with the median of 51 years. The weight of the women was 74 (65; 83.2) kg, the weight of the men was – 90.8 (82.6; 111.5) kg (hereafter the descriptive statistics are given as Me (LQ; UQ), where Me is the median, LQ is the lower quartile, UQ is the upper quartile).

In the group of healthy research participants there were 30.0 % of females (12 individuals) and 70.0 % of males (28 individuals). The age of the women ranged from 24 to 50 years with the median of 37 years; the age of the men was 31-49 years with the median 35 years. The weight of the women equaled 72 (67; 81) kg and the weight of the men made 83 (76.7; 85.2) kg.

The research was discussed and approved at the meeting of the Bioethics Committee of the State Institution “Sytenko Institute of Spine and Joint Pathology” of the NAMS of Ukraine (Minutes № 222 dated 20 December, 2021).

The indexes of pain and support ability were evaluated by means of VAS before and after a rehabilitation course. Skewness of loads (SL) “stop” was calculated in the following way. A patient stands on two weighing machines, with one leg on one machine and with the other leg – on the other, with both legs being shoulder width apart.

We evaluated which part of a body’s weight is in the left lower extremity, and which part is in the right one. The difference between bigger and smaller values is calculated, than it is divided into a bigger value and multiplied by 100.0%. Since the research groups had post-traumatic deformities of different locations (thigh, tibia and fibula bones), that affected the function of a body and lower extremities, standard scales of functional evaluation of muscles of hip and knee joints were not used.

Statistical processing of the research data was performed by means of a set of programs for general purposes STATISTICA (License Number: 139-956-866). Non-parametric methods were applied – Mann–Whitney U test (MWUT) was used to compare unrelated groups and Wilcoxon test was used to compare related groups.

In order to evaluate relative dynamics of a change in the indexes, additional indexes were calculated by the formula: $(I_{was}-I_{became})/I_{was}\cdot 100\%$, where I_{was} is the index value before treatment, I_{became} is the index value after treatment. Since these patients experienced pain, walking abnormalities and problems with their support ability, we developed a proprietary technology of massage and therapeutic gymnastics.

Every day all the patients experienced massage by the suggested technology based on the theory of T. Myers (2020), twice a day they did the suggested therapeutic gymnastics. The suggested massage technology includes the following: m. tibialis anterior, m. fibularis longus, tractus iliotibialis, m. tensor fascia latae, m. biceps femoris, m. adductor longus, m. rectus femoris, m. gluteus medius et maximus and massage of muscle attachments. Myofascial trigger points in the enumerated muscles were identified and massaged during massage procedures. That was done on both sides.

Therapeutic gymnastics was aimed at regenerating functional abilities of the same muscles. The complex included exercises aimed at restoring postural balance. Massage and therapeutic gymnastics were done daily during three weeks.

Results

Tabl. 1 and Tabl. 2 contain descriptive statistics of all the analyzed indexes.

Table 1. Research indexes of the female patients

Research indexes	Descriptive statistics						
	Average	Me	Minimum	Maximum	LQ	UQ	St. deviat.
Right l. e. (before treat.) (kg)	38.68	35.80	25.00	68.00	30.60	44.00	10.90
SL (before treat.) (%)	18.44	17.29	1.39	44.44	10.89	21.02	11.71
Left l. e. (before treat.) (kg)	37.49	37.20	23.30	48.60	34.00	42.70	6.67
Right l. e. (after treat.) (kg)	37.23	37.00	26.70	52.30	31.00	42.00	7.33
Left l. e. (after treat.) (kg)	38.14	38.00	26.00	52.00	34.00	42.00	6.75
SL (after treat.) (%)	4.77	2.70	.00	17.65	1.88	6.47	4.94
VAS (before treat.) (mm)	30.00	30.00	20.00	50.00	30.00	30.00	7.75
VAS (after treat.) (mm)	7.38	5.00	.00	20.00	5.00	10.00	4.36
Right l. e., dynamics (%)	1.57	1.79	-33.33	23.53	-1.32	6.82	11.60
SL, dynamics (%)	60.03	70.43	-86.33	100.00	49.41	92.51	43.70
Left l. e., dynamics (%)	-2.81	-2.44	-33.04	22.05	-11.59	3.85	14.35
VAS, dynamics (%)	72.86	75.00	.00	100.00	66.67	83.33	21.28

Table 2. Research indexes of the male patients

Research indexes	Descriptive statistics						
	Average	Me	Minimum	Maximum	LQ	UQ	St. deviat.
Right l. e. Before treat.) (kg)	51.14	47.20	20.50	92.00	42.40	59.00	16.21
SL (before treat.) (%)	22.18	11.86	1.78	60.58	8.60	35.95	18.99
Left l. e. (before treat.) (kg)	47.07	48.90	26.70	68.90	39.90	52.00	9.57
Right l. e. (after treat.) (kg)	48.06	46.20	30.60	79.00	41.00	54.40	11.83
Left l. e. (after treat.) (kg)	49.80	48.00	35.00	76.50	41.30	58.00	10.46
SL (after treat.) (%)	13.81	12.50	.24	33.48	3.29	24.05	11.25
VAS (before treat.) (mm)	30.00	30.00	20.00	60.00	20.00	40.00	11.06
VAS (after treat.) (mm)	12.63	10.00	.00	20.00	10.00	20.00	5.86
Right l. e., dynamics (%)	2.54	4.26	-49.27	33.38	-4.69	11.02	17.39
SL, dynamics (%)	18.88	38.95	-134.88	92.43	-24.90	63.11	65.62
Left l. e., dynamics (%)	-7.53	-1.50	-50.00	15.74	-22.70	7.69	20.33
VAS, dynamics (%)	53.07	66.67	0.00	100.00	33.33	75.00	29.69

Statistically significant dynamic changes in the females and males were observed by the indexes of VAS and SL (Fig. I-IV). The index of VAS (Fig. I) in the females fell from 30 mm (the median) to 5 ($p<0.01$; WT) as a result of treatment, i.e. the relative dynamics was 70.4%.

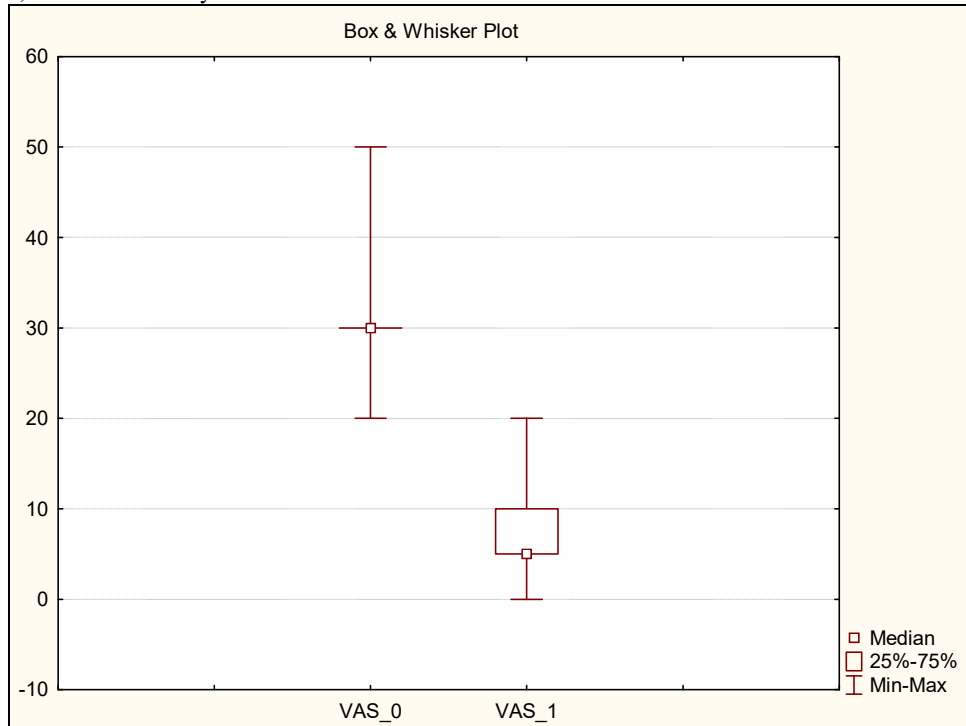


Figure I. Dynamics of the index of VAS in the female patients

The index SL (Fig. II) fell from 17.29% to 2.7% with the relative dynamics of 70.4%.

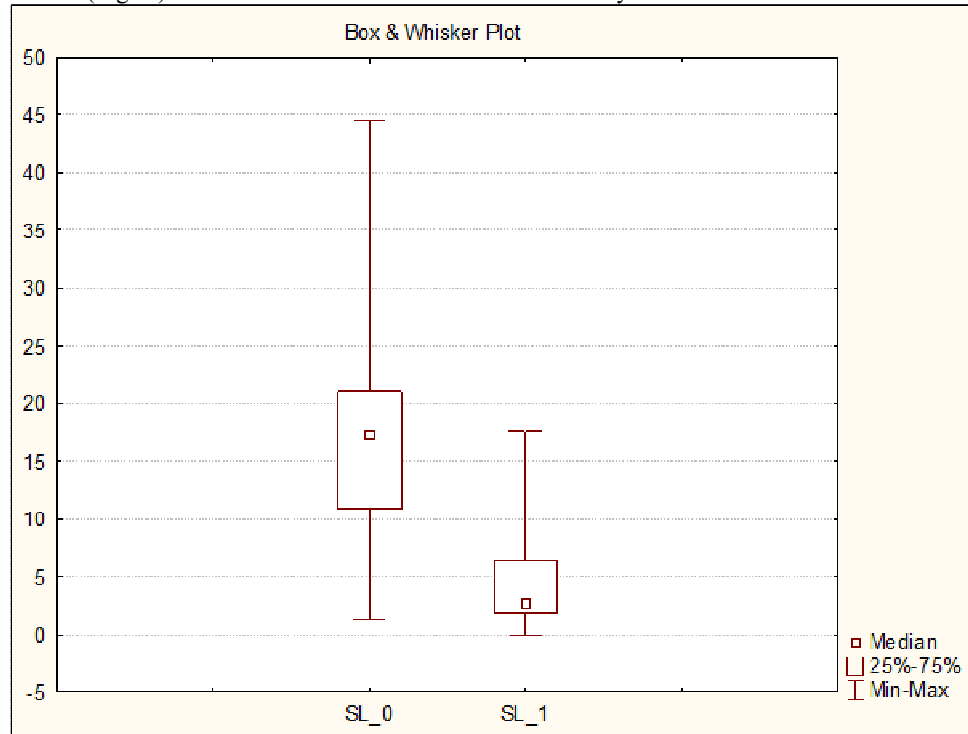


Figure II. Dynamics of the index of SL in the female patients

The index VAS (Fig. III) in the men decreased from 30 mm (the median) to 10 ($p < .01$; WT) as a result of treatment, i.e. the relative dynamics equaled 66.7%.

The index of SL (Fig. IV) ranged from 11.86% (8.6; 35.95) to 12.5% (3.29; 24) with the relative dynamics of 39.0%. In other words, as the descriptive statistics show, the index of the median grew a bit higher, but the quartiles fell considerably.

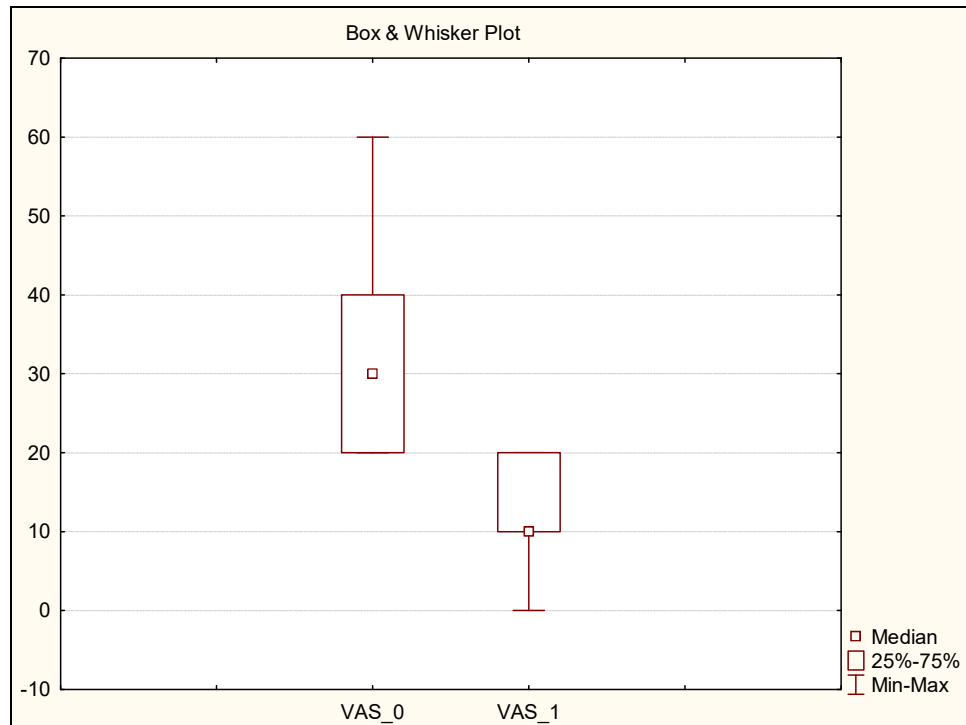


Figure III. Dynamics of the index of VAS in the male patients

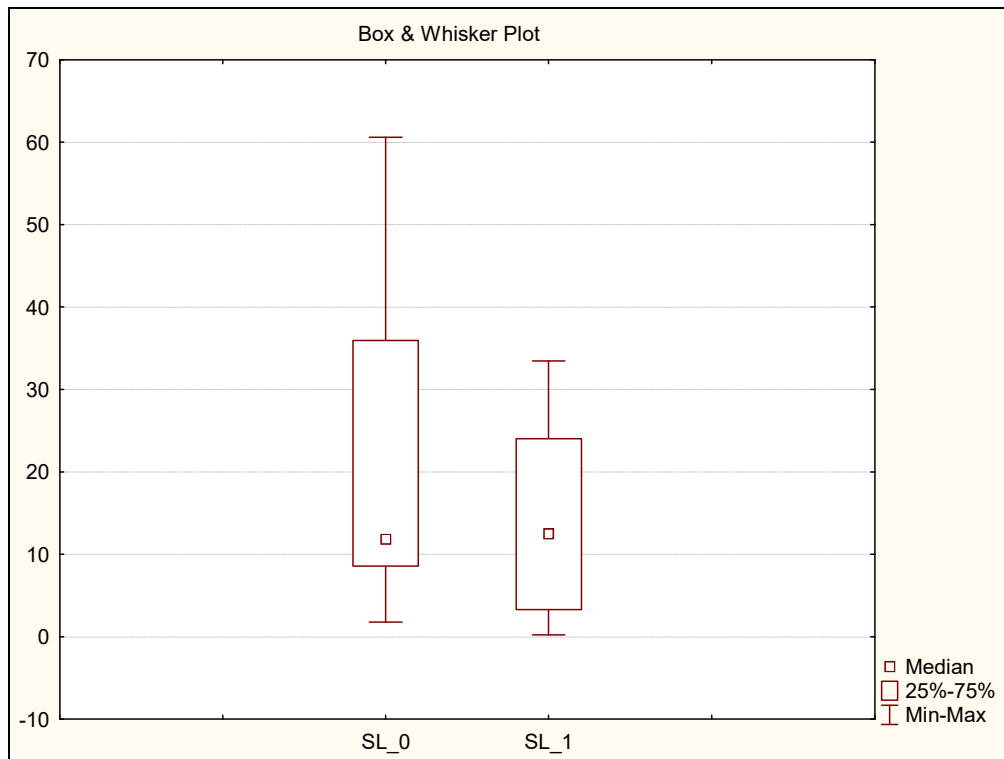


Figure IV. Dynamics of the index of SL in the male patients

Comparison of the groups allowed drawing a conclusion that, on the whole, the dynamics of both indexes (VAS and SL) was higher in the group of women in comparison with the group of men (Fig. V and VI). The differences were statistically significant ($p < .01$; MWUT).

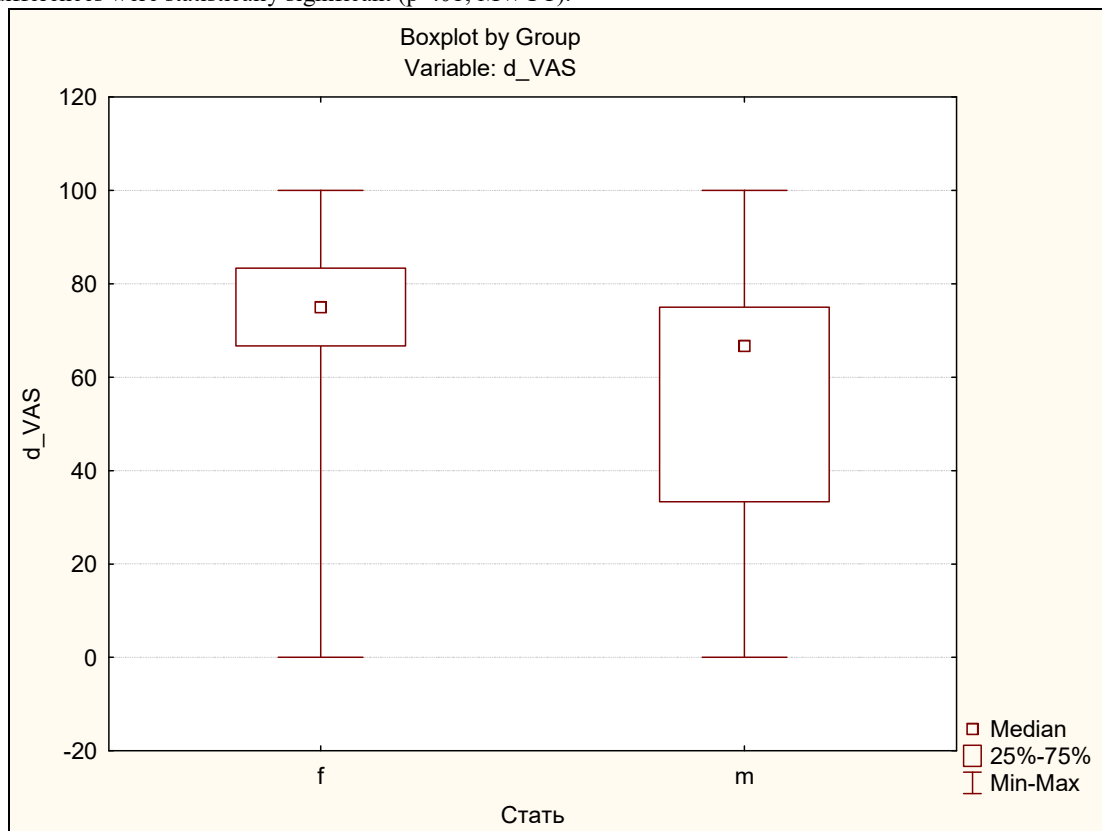


Figure V. Comparative dynamics of the index of VAS in the female and male patients

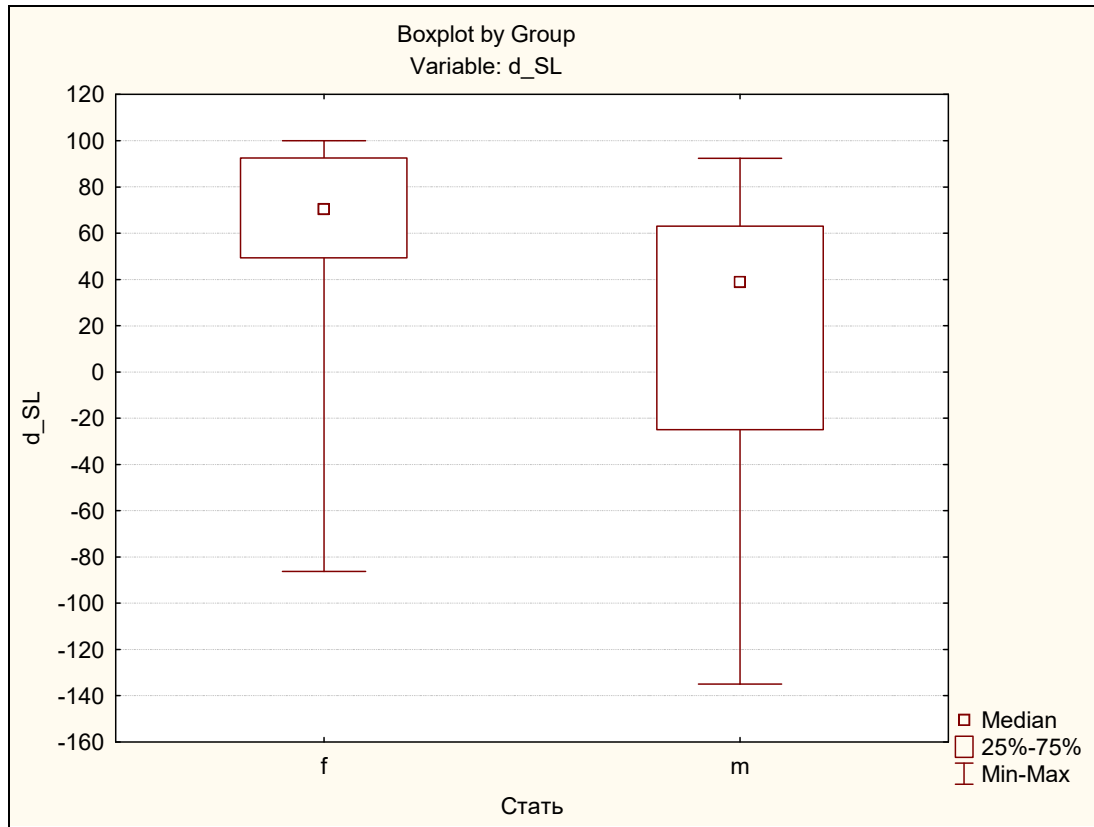


Figure VI. Comparative dynamics of the index of SL in the female and male patients

One of the research tasks was to evaluate the suggested methods for healthy volunteers. Statistically significant differences at the beginning of treatment were observed in the group of female patients only in the index of SL (3.03 % in the research participants, 17.29 % – in the group of patients) (Tabl. 1 and 3).

Table 3. Research index values in the female volunteers

Research indexes	Descriptive statistics						
	Average	Me	Minimum	Maximum	LQ	UQ	St. deviat.
Right l. e. (before treat.) (kg)	35.77	34.30	33.00	40.00	33.00	40.00	3.18
SL (before treat.) (%)	3.85	3.03	2.50	6.03	2.50	6.03	1.62
Left l. e. (before treat.) (kg)	35.83	36.50	32.00	39.00	32.00	39.00	3.03
Right l. e. (after treat.) (kg)	36.40	35.80	33.00	40.40	33.00	40.40	3.19
Left l. e. (after treat.) (kg)	36.93	36.20	34.00	40.60	34.00	40.60	2.87
SL (after treat.) (%)	1.51	1.10	.49	2.94	.49	2.94	1.09
Right l. e., dynamics (%)	-1.79	-1.00	-4.37	.00	-4.37	.00	1.95
SL, dynamics (%)	55.04	80.40	2.97	81.76	2.97	81.76	38.46
Left l. e., dynamics (%)	-3.18	-4.10	-6.25	.82	-6.25	.82	3.09

After treatment there were statistically significant differences in the indexes of SL (1.1 % in the research participants, 2.7 % – in the group of patients, $p=.01$, MWUT) and in the relative dynamics of support provided by a right lower extremity (-1.0 % in the research participants, 1.79 % – in the group of patients, $p=.04$, MWUT). Differences in the male research participants and patients were much more significant both at the beginning of treatment and after it (Tabl. 2, 4 and 5). However, the relative dynamics did not differ (Tabl. 5).

Table 4. Research index values of the male volunteers

Research indexes	Descriptive statistics						
	Average	Me	Minimum	Maximum	LQ	UQ	St. deviat.
Right l. e. (before treat.) (kg)	41.27	41.50	32.50	48.30	36.40	44.60	5.02
SL (before treat.) (%)	10.19	5.94	1.94	29.57	3.52	14.35	9.20
Left l. e. (before treat.) (kg)	39.40	38.70	31.20	50.10	37.10	40.50	5.31
Right l. e. (after treat.) (kg)	40.31	42.00	33.40	49.20	34.20	43.10	5.19
Left l. e. (after treat.) (kg)	42.03	41.20	36.20	50.20	40.60	42.80	3.94
SL (after treat.) (%)	5.92	2.32	1.90	21.96	1.99	5.66	6.85
Right l. e., dynamics (%)	1.82	-1.69	-5.23	24.60	-5.22	3.36	9.86
SL, dynamics (%)	36.60	40.72	2.06	83.83	4.71	55.65	27.18
Left l. e., dynamics (%)	-7.79	-2.75	-37.18	2.43	-10.21	-.20	12.78

Table 4. Levels of statistically significant differences in the research indexes in the healthy male research participants and patients at the beginning of treatment and after treatment

Research indexes	U	p
Right l. e. (before treat.) (kg)	124	.00
SL (before treat.) (%)	172	.04
Left lower. e. (before treat.) (kg)	130	.00
Right l. e. (after treat.) (kg)	156	.02
Left l. e. (after treat.) (kg)	144	.01
SL (after treat.) (%)	140	.01
Right l. e., dynamics (%)	200	.16
SL, dynamics (%)	256	.84
Left lower. e., dynamics (%)	212	.25

Note: U – value of Mann-Whitney statistics; p – level of significance.

There was additional evaluation of differences between the patients after treatment and the healthy volunteers at the beginning of treatment. There were no differences in the women (i.e., the indexes of support provided by the right lower extremity (after treatment), the left lower extremity (after treatment) and SL (after treatment) became such as those in the healthy volunteers before treatment, however, there were no such results concerning the index of SL in the men.

Analyzing these results, we can see that the women and the men before treatment loaded their right lower extremities much more than their left lower extremities. The maximum load for the right lower extremity in the women was 68 kg in comparison with the left lower extremity – 48 kg. The standard deviation equaled 10.9 on the right and 6.6 on the left (see Tabl. 1). The maximum load for the right lower extremity was 92 kg in the men in comparison with 68 kg for the left lower extremity. The standard deviation equaled 16.21 on the right and 9.57 on the left (see Tabl. 2). After treatment there was regeneration of uniform loads between the extremities in both groups, but the median of the dynamics of SL in the women was 70.43%, that is twice higher than in the men – 38.95%. It shows that the female patients recovered better than the male patients.

Discussions

We consider that the obtained results showing that the patients loaded their right lower extremity more in comparison with their left lower extremity before treatment are related to a dominant lower extremity. In our opinion, uniform loads between the dominant and non-dominant lower extremities are related to the following factors. Firstly, massage and therapeutic gymnastics are aimed at recovering support ability of a body and lower extremities and also appropriate distribution of body weight between the extremities. This mainly differentiates this approach from the available standard rehabilitation systems. We applied the theory of T. Mayers (2020) in selection of muscles and ligaments in cases of post-traumatic deformities of long bones of lower extremities. According to the hypothesis of T. Mayers (2020), influencing anatomically and functionally related muscles and ligaments, it is possible to affect the pelvic inclination and distribution of loads for lower extremities (Fig. VII). The balance of such muscles as m. tibialis anterior and m. fibularis longus and ligaments supporting them changes if there is valgus or virus deformities in ankle joints. The balance of these muscles also changes when there is such a deformity of the forefoot as Hallux valgus. The balance of such muscles as tractus iliotibialis, m. tensor fascia latae, m. biceps femoris, m. adductor longus, m. rectus femoris, m. gluteus medius et maximus and ligaments supporting them changes under the pelvic inclination and varus or valgus deformities in knee joints. V. Staude and Y. Radzyshevska (2021) proved in their study that it is possible to affect X-ray parameters of the pelvis and spine that changes the pelvic inclination and increases support ability of the pelvis and body by means of massage and selective therapeutic gymnastics (Staude & Radzyshevska, 2021).

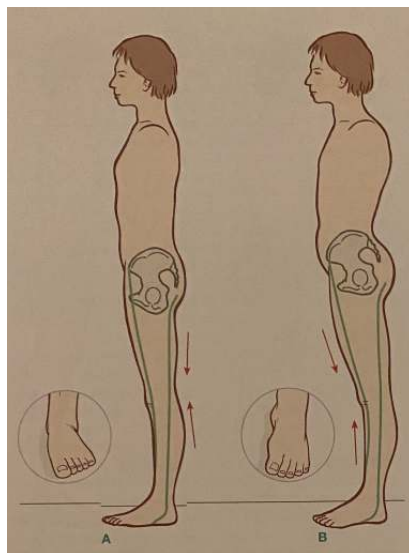


Figure VII. The hypothesis of T. Mayers (2020) about a change in the balance of muscles and ligaments under a change in the pelvic inclination and varus or valgus deformities in ankle joints

Some authors state that training for muscles of a non-dominant lower extremity in athletes regenerates the balance between muscles of different sides and increases functional abilities of both lower extremities (Nadzalan et al., 2021). Scientists maintain that athletes in steeplechase who do not have a dominant leg in training have a more balanced posture than those with a dominant leg. They also emphasize the importance of training for a non-dominant leg in such athletes (Wojciechowska-Maszkowska et al., 2021).

Secondly, the patients have a mindset oriented towards distribution of loads between dominant and non-dominant legs and possess an appropriate instrument of control that boosts a training process. An appropriate instrument of control means that all the patients were taught how to use usual bathroom scales for control of loads between their lower extremities. It is very important that all the patients went in for sports before traumas and had an appropriate psycho-emotional state of expecting a victory (Popovych, I., et. al., 2021b; 2022a; 2022b; 2022d). I. Popovych et al. (2021a; 2022c) thinks that men manage their emotions better, at the same time, women are more expressive. The fact that the women had better indexes of regeneration than the men did can be related to gender stereotypes.

Conclusions

The suggested system of massage and selective therapeutic gymnastics based on the hypothesis of anatomically and functionally connected muscles and ligaments considerably reduces pain and regenerates support ability of the body and lower extremities in individuals with consequences of traumas of long bones of the lower extremities who went in for sports before traumas. Massage was targeted at myofascial trigger points of m. tibialis anterior, m. fibularis longus, tractus iliotibialis, m. tensor fascia latae, m. biceps femoris, m. adductor longus, m. rectus femoris, m. gluteus medius et maximus and the places of attachment of these muscles from both sides. Selective gymnastics was aimed at restoring the balance of m. tibialis anterior, m. fibularis longus, tractus iliotibialis, m. Tensor fascia latae, m. biceps femoris, m. adductor longus, m. rectus femoris, m. gluteus medius et maximus and the places of attachment of these muscles from both sides. The complex of therapeutic exercises involved exercises aimed at restoring postural balance. It is very important that all the patients went in for sports before traumas and had an appropriate psycho-emotional state of expecting a victory.

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