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RESTORATION OF WALKING FUNCTION IN ELDERLY PEOPLE WITH TYPE 2 DIABETES AFTER AMPUTATION OF THE MIDDLE THIRD OF THE LOWER LEG

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Abstract. The article presents the content and results of the course of comprehensive introduction of forms and means of physical therapy aimed at restoration of walking function in elderly people with type 2 diabetes mellitus after amputation of the middle third of the lower leg. Objective data are presented proving the effectiveness of the course, as a result of which the subjects' step symmetry on the operated limb improved by 12% from $58.37 \pm 3.71\%$ to $51 \pm 1.00\%$ and step symmetry on the intact limb increased from $42.87 \pm 1.76\%$ to $49.0 \pm 1.00\%$. Walking speed increased by 36.6%, walking cadence increased by 34.8%. Support reaction force (kg) on the prosthesis increased by 13% and in the intact limb by 12%. Pain sensitivity of the intact limb decreased by 3.3% and pain sensitivity of the stump increased by 42.5%.

Keywords: restoration of walking function, amputation of the middle third of the lower leg, elderly people, diabetes mellitus, mechanotherapy, controlled walking, Nordic walking, therapeutic exercises.

Introduction. In the structure of endocrine system pathologies diabetes takes about 60-70% of their total number. According to the International Diabetes Federation, a number of patients all over the world is 500 million (data from 2021). Risk factors of type 2 diabetes development include obesity, genetic predisposition, increased blood cholesterol, sedentary lifestyle et al. Type 2 diabetes often starts developing in middle and old age and causes great damage to the body, especially to the nervous system and blood vessels [1, 2]. One of late diabetes complications is lower limb gangrene resulting in amputation, which is a serious injury. After amputation of the middle third of the lower leg, the static and dynamic work of the skeletal muscles is impaired, motor stereotypes are disturbed, coordination and balance function deteriorates, contractures occur in nearby joints, and the quality of life deteriorates [3-5]. Prosthesis after amputation is an integral part of recovery, the effectiveness of which depends on the quality of prosthetic implant construction and preparation for the surgery. The level of amputation of the operated limb, the stump condition, and training for the correct use of the prosthetic implant play a crucial role [6]. The process of walking function restoration is an integral part of

adaptation of this contingent to new living conditions, in which the key aspect is the complex application of means and forms of physical therapy [7, 8].

Aim – to restore the walking function in elderly people with type 2 diabetes after amputation of the middle third of the lower leg.

Methods and organization. The study was conducted in the Center of Innovation Techniques in Orthopedics, from June to August 2023, it included men ($n=8$) diagnosed with type 2 diabetes after amputation of the middle third of the lower leg in the long-term postoperative period. The time after amputation was not earlier than 6 months. The mean age of the subjects was 61.0 ± 1.7 years. The study of walking was carried out with motor testing on the C-mill rehabilitation complex (Physiocom). The following parameters were evaluated: step width (%); step symmetry on the intact limb (%) and on the operated limb (%); walking speed (km/h) and cadence (step/min); support reaction on the operated limb (kg) and on the intact limb (kg). The assessment of pain and tactile sensitivity at rest was studied with the visual analogue scale (VAS). The arithmetic mean ($\bar{X}$), standard deviation (σ) were calculated using math-and-stats methods. The degree of reliability of the obtained data of

parametric indicators was identified with the Student's T-test, the data of nonparametric indices were assessed with the Wilcoxon's signed rank test.

The course for restoring the walking function by means of physical therapy lasted for 70 days and included three periods: introductory – 20 days, main – 30 days and final – 20 days, each of them solved the following tasks: improvement of the state of the cardio-respiratory system; blood glucose reduction; carbohydrate metabolism normalization; preparing the body for gradually increasing loads; patient verticalization; improvement of blood circulation in the lower limbs and in the whole body; development of the proper walking pattern; psychoemotional state improvement; improvement and training of coordination and balance functions; elimination of contractures and stiffness in the operated limb joints; strengthening of the operated and superior muscles of the stump and muscles of the intact lower limb; increase in the strength of the trunk and shoulder girdle muscles.

In the introductory period of the recovery course, therapeutic exercises were performed every other day for 35-45 minutes, the main part consisted of special exercises for coordination and balance, stretching and relaxing muscles, with objects, on equipment, phantom exercises for the stump muscles – at an average pace while sitting and standing up. Therapeutic massage is performed in a course of 10 procedures every other day for 15-20 minutes in order to reduce muscle fatigue, relieve pain, restore and strengthen muscle tone, improve blood and lymph circulation. Controlled walking introduced daily, the cadence was 60-70 steps/min, the distance was 150 m, gradually increased to 1 km. Physical therapy and independent sessions were conducted every other day.

In the main period of the recovery course, the following tasks were additionally addressed: improvement of the upper and lower limb muscle blood and nerve supply;

strengthening of upper limb support; complication prevention. The means and forms were supplemented with Nordic walking performed daily for 25-35 minutes; circular shower procedures with gradual reduction of water temperature from 36°C to 25°C. The time was increased to 45-60 minutes. Special exercises were aimed at strengthening the muscles of the upper and lower limbs, developing the proper walking pattern, exercises in stepping, training and improving the balance function, strengthening the trunk and shoulder girdle muscles. The therapeutic exercise sessions included exercises on the C-mill rehabilitation complex and the COBS force plate for 15-20 minutes each, with rest pauses (1 minute) between sets. Therapeutic massage (15 procedures) was performed on days when no physiotherapy procedures carried out. Exercises on machines (C-mill, COBS) included walking on a treadmill and walking with parallel bars. In addition, exercises on an unstable platform were included, performed every other day for 15-20 min with gradual complication and, as the movement coordination improved, without additional support. This period also included game elements (throwing a ball to the patient, etc.).

In the final period (20 days) the following tasks were solved: improving the total body endurance; metabolism normalization. The following forms of recovery were included in this period: therapeutic exercise, therapeutic massage, dosed walking, independent sessions. During this period, the time of therapeutic exercise sessions introduced every other day was increased up to 50-60 min. The methods of independent sessions and therapeutic massage remained unchanged. Walking time, carried out every other day at a cadence of 90-120 steps per minute with increasing the distance up to 3-4 km, was 30 min.

Results and discussion. After the recovery course, the study population showed an improved walking function in the studied parameters (table).

Table

Changes in motor test data on the C-mill of the studied group before and after the walking function restoration course, $X \pm \sigma$

Motor test	Before	After	$P \geq$
Step width, m	0.156 ± 0.03	0.177 ± 0.02	0.05
Step symmetry on the operated limb, %	58.37 ± 3.71	51.0 ± 1.00	0.05
Step symmetry on the intact limb, %	42.87 ± 1.76	49.0 ± 1.00	0.05
Speed, km/h	1.49 ± 0.17	2.35 ± 0.24	0.05
Cadence, steps/min	58.88 ± 5.80	79.37 ± 4.97	0.05
Support reaction on the operated limb, kg	69.92 ± 17.13	79.92 ± 12.65	0.05
Support reaction on the intact limb, kg	70.93 ± 16.89	80.03 ± 12.66	0.05

According to the results of the study, there was an increase in the step width from 0.156 ± 0.03 to 0.177 ± 0.02 m with an improvement of 12%. In assessing the step symmetry, there was a decrease in the values on the operated limb from 58.37 ± 3.71 to $51 \pm 1.00\%$. The step symmetry on the intact limb increased from 42.87 ± 1.76 to $49.0 \pm 1.00\%$.

A comparison of walking speed showed an increase of 36.6%: from 1.49 ± 0.17 to 2.35 ± 0.24 km/h. The walking cadence increased by 25.8%: from 58.88 ± 5.80 to 79.37 ± 4.79 steps/min. There was also an increase in the support reaction on the operated and the intact limb from 69.92 ± 17.13 to 79.92 ± 12.65 kg and from 70.93 ± 16.89 to 80.03 ± 12.66 kg respectively.

Pain sensitivity on the intact limb has

reduced by 3.3%: from 4 ± 0.71 to 3.87 ± 0.60 points, Pain sensitivity on the operated limb has increased by 42.5%: from 1.87 ± 1.17 to 3.25 ± 0.66 points.

Conclusion. Comprehensive introduction of means and forms of physical therapy, such as therapeutic exercise, therapeutic massage, mechanotherapy, controlled walking, Nordic walking, hydrotherapy, physiotherapy, contributed to an increase in step width, an increase in walking speed, an improvement in the support response on the operated and the intact limbs; a decrease in pain sensitivity on the intact limb and an increase on the stump in the studied patients with type 2 diabetes after amputation of the middle third of the lower leg, reflecting the return of the lost sensitivity of the operated limb.

Conflict of interest. The author declares no conflict of interest.

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