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Original Article

Effectiveness of physical therapy interventions for young adults after lower limb transtibial amputation

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Abstract
Over recent years there has been a steady increase in the number of people with amputation deformities of the lower limbs. To a large extent, this is due to the increased incidence of injuries, especially among working-age population, caused by traffic accidents, accidents at work, man-made and natural disasters, military actions, and injuries in everyday life. Theoretical analysis and generalization, sociological methods, expert evaluation method, pedagogical observation, pedagogical experiment, methods of mathematical statistics. Pedagogical experiment involving 86 people with the lower limb transtibial amputation was conducted. The effectiveness of the author's comprehensive program of physical therapy for young adults after the lower limb transtibial amputation at the stage of after hospital care, was acknowledged by intra-group changes and higher key indicators values in the participants of the experimental group, which for men and women are proved by significant ($p \leq 0.05$-0.01) improvement of the results of manual and muscle testing with achievement, of physical fitness and most baropodometry indicators, etc. Based on the research results, for the first time the structure and content of the physical rehabilitation program was scientifically substantiated; it was found out that the indicators characterizing the functional.
Key words: physical rehabilitation, amputation, lower limb, the stage of after hospital care.

Introduction

Means of physical rehabilitation occupy a leading place in modern science (Gorshova, 2017; Lazareva, 2017). Over recent years, there has been a steady increase in the number of people with amputation deformities of the lower limbs. To a large extent, this is due to the increased incidence of injuries, especially among working-age population, caused by traffic accidents, accidents at work, man-made and natural disasters, military actions, and injuries in everyday life (Kawa, 2014; Herasymenko, 2016).

The issue of rehabilitation of persons with sequels to the lower limbs amputation deformities is determined by significant locomotor disorders, limiting the possibilities of movement and self-care, postural disorder, restructuring of all functional systems, changing in the metabolic processes, reducing the body's reserve capacity, tolerance to physical exertion and physical performance and, consequently, the pronounced limitation of vital activity (Bashir, 2005; Briskin, 2016). The expert data testify to the fact that the people with amputation of the lower extremities are the most difficult in terms of the rehabilitation treatment determined by the multifactorial process, which contains solutions for social and living, medical, psychological, recovery, compensatory and other issues (Herasymenko, 2011; Zviriaka, 2013).

Over recent years the prosthetic industry has developed rapidly in the world. The development and introduction of modern technologies and tools for manufacturing the prosthetic and orthopedic products requires that new approaches to the further rehabilitation of persons with special needs were found by the scientists and specialists of the industry. The fundamental difference of the structure of the construction of a modern prosthesis and a stump socket, its static-dynamic indicators and the influence on the residual limb and the human body as a whole, in turn, requires a revision of the generally accepted standards and methods of preparation for prosthetics and restoration of the working capacity of young people after traumatic amputations of the lower limbs (Young, 2014; Herasymenko, 2016).

The common notion that the ultimate goal of rehabilitation of persons after the lower limb amputation is compensation of lost function of independent movement (Stasik, 2008; Sharova, 2014) in practice is limited to

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the tasks of prosthetics and training in the use of a prosthesis. At the same time, observations of a number of specialists suggest that effective rehabilitation of this contingent depends not only on qualitative prosthetics, but is largely provided by the level of adaptation of the basic systems of vital activity of the body (Kurdybailo, 2001; Wasiak, 2006; Wolthuis, 2006; Winell, 2006).

In addition, the vast majority of sources of scientific and methodological literature highlight and justify the methods of restorative drug treatment, the classification of amputation impairments, the fitting of prostheses, etc., and does not provide exhaustive recommendations for conducting a holistic process of physical therapy for persons with the lower limb transtibial amputation, in particular at the stage of after hospital care (Vasylchenko, 2014; Wilczyńska, 2015; Szafraniec, 2016).

Thus, the need to develop new and improve existing approaches to physical therapy for persons with amputation stumps of the lower extremities against the background of a growing number of individuals with these amputation impairments form an actual scientific and practical task with the purpose of the effective implementation of the rehabilitation potential at the stage of the after hospital care, which led to selecting the abovementioned research topic.

Material and methods

In the course of the study, the following methods were used: theoretical analysis and generalization, sociological methods, expert evaluation method, pedagogical observation, pedagogical experiment, methods of mathematical statistics (for processing empirical data at various stages of the study); sociological (survey and collection of anamnesis for clarifying the state of health, determining the subjective evaluation of the previously conducted rehabilitation activities at various stages of rehabilitation, expert evaluation of the quality characteristics of walking of persons with the lower limb transtibial amputation at different stages of the study); biomedical methods (somatoscopy, anthropometry, goniometry, manual muscle testing (MMT), studies of hemodynamic parameters and level of physical performance, motor tests, tensometry); pedagogical observation (for obtaining empirical information on the state of persons with the lower limb transtibial amputation at different stages of the study); pedagogical experiment (the test of the effectiveness of the author's program of physical rehabilitation for persons with the lower limb transtibial amputation at the stage of the after hospital care); psychological (test - well-being, activity, mood,(WAM); quality of life test (SF-36)); methods of mathematical statistics (for processing empirical data at various stages of the study).

A pedagogical experiment involved 86 young adults with the lower limb transtibial amputation, which were divided into two groups of 43 people in this way: main group (n=43, 35 men and 8 women) and control group (n=43, 32 men and 11 women), with a period after amputation from 1 to 5 months. Formative pedagogical experiment was organized at state and private orthopedic enterprises.

Results

Studies of the specialists provide evidence that in the human body affected by traumatic amputation, not only the motor system changes, but also serious impairments of the cardiovascular, respiratory and nervous systems are identified in the psychic sphere, and the overall decrease in motor activity only slows down the recovery of these systems. Only one third of the patients, who use prosthetic products, actively use them in their daily activities. Disadvantages of prosthetics, unpreparedness of functional systems to the new conditions of movement and, in general, the absence of a comprehensive program of physical therapy are some of the main reasons for the low effectiveness of rehabilitation of persons with consequences of the lower limb amputation.

After amputation, the functional and structural changes develop in the vital systems. Compensation as a biological reaction is not episodic, but a holistic integrated process, going through certain stages that differ by different functional states. The formation of a stable, qualitatively new functional state, providing living conditions in relations between the external and internal environment, should be considered as completion of the adaptation process. The objectives of physical therapy is to predict the required and appropriate compensatory changes in the human body with amputation impairment and active influence on these processes by means of physical therapy at all stages of adaptation to new conditions of vital activity.

Locomotor activity is one of the main factors affecting the functional and structural systems of the body, an instrument of active influence on the adaptation processes. The available means of physical therapy for the basic elements of locomotor activity occupy the leading place in the analysed available approaches and in the methods of application of physical therapy means, which also have, proven by experts, parameters of dosing, consistency of training sessions, the diversity of structure and content, recommendations for conducting and objectification of the results evaluation. Analysis of scientific and methodological literature on the rehabilitation of persons with effects of a lower limb amputation indicates the main contradiction associated with the presence of a qualitative substantiation of the processes of prosthetics and gait teaching and at the same time, available techniques (programs) do not take into consideration the peculiarities of the amputees' functional capacities, depending on age and limb loss level which directly determines the predicted outcome of recovery and / or compensation for lost functions.

The study of the condition of individuals should be conducted taking into account multidirectional indicators. In addition to the data of anamnesis, somatoscopy, anthropometry, manual-muscular testing, goniometry, it is advisable to objectify the level of readiness for rehabilitation interventions with the use of indicators of physical fitness (squats; bouncing on the preserved leg; flexion and extension of arms in front lying support; sit-up from the back-lying position; balance on the preserved leg; balance on the knee of the residual limb); physical performance and the response of hemodynamic indicators to the load by using manual veloergometry (PWC150).

The main indicators are the objective characteristics of walking, the results of an expert evaluation of the quality (external) characteristics of gait and, in particular, accounting for a set of data obtained with the help of baropodometry. An additional factor of the rehabilitation influence on individuals with lower limb transtibial amputation is the psychoemotional state, which was expediently characterized by the methods of WAM (well-being, activity, mood) and the assessment of the quality of life – the 36-item Short Form Health Survey - the SF-36.

The results of the study of individuals who required physical therapy on the stage of after hospital showed the presence of a larger proportion of men (77.9 %) and those at the age of 26-31. The highest share of amputations in both men and women was a result of road traffic accidents (64.2 and 57.9 % of the total number of gender group). The output parameters of persons with the lower limb transtibial amputation when entering rehabilitation were as follows: the state of the remaining stump muscles at the level of muscle groups of the thigh was in the majority at a good level (87.2-94.1 % of the total number of subjects) and somewhat lower for the muscular groups of the tibia (65.1-82.5 %) with the available unsatisfactory rates; according to the results of manual and muscular testing, all persons who needed rehabilitation showed the result at the level of 4 points (31.3-78.9 %) and 5 points (21.1-68.1 %) according to the corresponding scale; according to the dynamometry indicators of stump movements and preserved limb, a disproportion (15.2-49.4 % of the preserved limb level) was recorded with less varying indices in the group of men; The largest part of people involved in the physical therapy program for the period from 2 to 4 months after the completion of the hospital rehabilitation period (59.3 % of the total number of patients), which confirmed the tendency of loss of functional capacities with delaying the transition to physical therapy at the stage of the after hospital care.

The functional state of subjects with lower limb transtibial amputation is characterized by a generally low locomotor activity, unpreparedness for walking on the prosthesis against the background of a pronounced decrease in the strength and functional parameters of the muscular systems. This is manifested in low physical fitness and performance, low expert assessments of indicators of gait characteristics, inappropriate baropodometry indicators.

All combined, this was reflected on the psychoemotional state of individuals with lower limb transtibial amputation at the time of admission to the program of physical therapy at the stage of after hospital care, which is confirmed by the results of the WAM technique (well-being 3.04-3.08; activity 3.00-3.13; mood 2.91-3.26 points) and life quality scale SF-36 (physical component 25.69-38.73 (units) and mental component 29.05-35.37 (units)). In total, at this stage of the research, it was revealed that for subjects (of different sexes) with lower limb amputation at the stage of after hospital care, there is a need to rearrange the activity of the body's functional systems for high-quality and efficient work in the new conditions of movement on the prosthesis. This should be ensured by application of a substantiated comprehensive program of physical therapy with the allocation and specification of the main tasks, taking into account the obtained results of objectified pedagogical observation.

The main components of the program were: therapeutic physical culture, massage, the fundamentals of bandaging, combined developing exercises, gait training, exercises on training simulators. The objective need for substantiation of modern approaches to physical therapy for individuals with lower limb transtibial amputation at the stage of the after hospital care, is to take into consideration the principle of the maximum permissible activity which leads to changes in the structure and content of rehabilitation methods. They include the use of training devices for body weight regulation, shifting the emphasis of exercises in the direction of active extension, gait training and directing the massage, using the Saarbrücken prosthesis against the background of a reduction in the volume of combined developing exercises and bandaging.

Objective factors of the process of physical therapy of subjects with lower limb transtibial amputation at the stage of after hospital care determined the duration of the pedagogical experiment within three months with 26 training sessions (2-3 times a week). Experimental testing of the comprehensive program of physical therapy for individuals with lower limb transtibial amputation at the stage of after hospital care, made it possible to establish general more pronounced positive impact of the author's approach. There are significant increases ($p \leq 0.05$-0.01) in the majority of indicators that determine the purpose of the appropriate stage of physical therapy in subjects with this amputation impairment (Table 1-3).

Table 1. Changes in dynamometric parameters of stump movements and preserved limb during pedagogical experiment (n = 86).

Parameters (kg/s)	Stages of the study							
	Before the pedagogical experiment				After the pedagogical experiment			
	CG		MG		CG		MG	
	M (n=32)	W (n=11)	M (n=35)	W (n=8)	M (n=32)	W (n=11)	M (n=35)	W (n=8)
The tibia of the preserved limb								
Flexion	36.00[1,3] ±3.06	34.45[1] ±1.95	38.49[3] ±2.93	34.25 ±2.00	39.22[1] ±2.70	37.82[1,4] ±1.29	38.89 ±2.50	36.25[4] ±1.25
Extension	52.84[3] ±3.11	42.45[1,3] ±3.14	48.91[2,3] ±3.33	46.63[3] ±1.28	52.44[4] ±1.93	46.18[1] ±2.20	50.26[2,4] ±2.17	48.50 ±2.38
Hip adduction	40.66[1] ±4.20	36.82[1] ±2.05	38.97[2] ±3.00	35.63[2] ±1.97	45.81[1,4] ±3.46	43.64[1] ±1.97	41.86[2,4] ±2.26	39.75[2] ±1.81
Hip abduction	34.66[1] ±2.62	29.00[1] ±1.82	35.46[2] ±2.46	29,63[2] ±1.72	38.44[1] ±2.34	35.45[1] ±1.67	37.97[2] ±2.47	35.13[2] ±0.66
Residual limb								
Flexion	29.44 ±3.79	24.36[1] ±2.40	30.97[2] ±3.12	24.88[2] ±0.69	30.38[4] ±3.11	27.36[1,4] ±1.85	33.46[2,4] ±2.07	30.63[2,4] ±0.88
Extension	37.60[1] ±2.73	31.91 ±2.66	37.97[2] ±3.06	32.38[2] ±1.97	39.56[1,4] ±3.05	34.18[4] ±2.17	42.97[2,4] ±1.48	41.00[2,4] ±1.75
Hip adduction	30.91[1] ±2.73	29.64 ±3.92	31.40[2] ±3.18	28.63[2] ±3.13	33.50[1,4] ±3.43	31.73[4] ±2.25	35.43[2,4] ±2.10	34.13[2,4] ±1.63
Hip abduction	25.81[1] ±2.86	21.91[1] ±1.92	26.31[2] ±2.53	22.38[2] ±2.38	28.25[1,4] ±2.89	25.82[1,4] ±1.26	31.69[2,4] ±1.76	28.13[2,4] ±1.38

Notes: CG - control group; MG - main group; M - men; F - women; [1] – significance of differences in the indices of the control group before and after the pedagogical experiment ($p \leq 0.05$); [2] – significance of differences in the indices of the main group before and after the pedagogical experiment ($p \leq 0.05$); [3] – significance of differences in the indices of the control and main groups before the pedagogical experiment ($p \leq 0.05$); [4] – significance of differences in the indices of the control and main groups after the pedagogical experiment ($p \leq 0.05$).

The effectiveness of the author's approach to the development of the comprehensive program of physical therapy is confirmed by such data.

Intra-group changes ($p \leq 0.05$-0.01) in the representatives of the main groups were recorded according to the following indices: dynamometry of movements of residual limb and preserved limb. In all cases, there is a significant ($p \leq 0.05$) increase in the indices of representatives of the main groups: flexion (8.04 % - men and 23.11 -women); extension (13.17 % - men and 26.62 % -women); hip adduction (12.83 % - men and 19.21 - women); hip abduction (20.45 % - men and 25.69 % - women). This occurred against the background of an increase in individual indicators of the preserved limb: extension (2.72 % - men); hip adduction (7.41 %- men and 11.56 %- women); hip abduction (7.09 % - men and 18.56 % - women);

The advantage ($p \leq 0.05$-0.01) of the representatives of the main group over the control group at the end of the pedagogical experiment in the intergroup comparison was in flexion (10.14 % - men and 12.32 % - women); extension (8.62 % - men and 17.03 % - women); hip adduction (5.88 % - men and 7.56 % - women); hip abduction (12.18 % - men and 8.71 % for women);

In addition, intra-group changes ($p \leq 0.05$-0.01) in the representatives of the main groups were recorded in physical fitness according to the following control exercises: squats (by 60.98 % - men and by 70.73 % - women); bouncing (by 32.74 % - men and by 25.28 % - women); flexion and extension of arms in front lying support (by 23.65 % - men and by 31.19 % - women); sit-up from the back-lying position (by 55.99 % - men and by 142.08 % - women); balance on the preserved limb (by 46.96 - only women); balance on the knee of the residual limb (by 568.99 % - men and by 332.44 % - women);

The advantage ($p \leq 0.05$-0.01) of the representatives of the main group over the control group in physical fitness was as follows: bouncing (by 5.10 % - men); balance on the knee of the residual limb (by 67.25 % - men and by 65.58 % - women).

Table 2. Changes in the results of physical fitness tests for persons with lower limb transtibial amputation during the pedagogical experiment

Gait parameters	Stages of the study							
	Before the pedagogical experiment				Before the pedagogical experiment			
	CG		MG		CG		MG	
	M (n=32)	W (n=11)	M (n=35)	W (n=8)	M (n=32)	W (n=11)	M (n=35)	W (n=8)
Squats (times)	9,47[1,3] ±1,99	8,00[1] ±2,00	7,51[2,3] ±1,33	6,75[2] ±1,69	13,03[1,4] ±1,53	11,45[1] ±1,32	12,09[2,4] ±1,39	11,50[2] ±1,38
Bouncing (times)	27,13[1,3] ±2,53	22,18[1] ±2,93	29,57[2,3] ±3,90	24,25[2] ±1,00	35,69[1,4] ±2,02	33,64[1,4] ±2,46	37,51[2,4] ±3,71	30,38[2,4] ±1,13
Flexion and extension of arms in the front lying support (times)	18,81[1] ±3,00	11,45[1] ±3,14	17,63[2] ±4,49	10,50[2] ±1,63	25,38[1,4] ±4,63	16,09[1,4] ±1,22	21,80[2,4] ±3,69	13,88[2,4] ±1,66
Sit-up from the back lying position (times)	11,66[1] ±1,93	6,36[1] ±1,67	10,77[2] ±2,39	6,25[2] ±1,06	17,09[1] ±1,79	15,27[1] ±1,39	16,80[2] ±1,74	15,13[2] ±1,16
balance on the preserved leg (c)	22,13 ±5,31	16,45[1] ±3,49	22,46 ±6,17	14,63[2] ±3,38	24,28 ±3,38	21,00[1] ±2,55	23,71 ±4,37	21,50[2] ±2,50
Balance on the knee of the residual limb (c)	1,59[1] ±1,02	2,09[1] ±1,19	1,29[2] ±1,36	1,88[2] ±0,69	5,16[1,4] ±1,28	4,91[1,4] ±1,21	8,63[2,4] ±2,58	8,13[2,4] ±1,63

Notes: CG - control group; MG - main group; M - men; F - women; [1] – significance of differences in the indices of the control group before and after the pedagogical experiment ($p \leq 0.05$); [2] – significance of differences in the indices of the main group before and after the pedagogical experiment ($p \leq 0.05$); [3] – significance of differences in the indices of the control and main groups before the pedagogical experiment ($p \leq 0.05$); [4] – significance of differences in the indices of the control and main groups after the pedagogical experiment ($p \leq 0.05$).

Table 3 Changes in the basic indices of baropodometry of persons with lower limb transtibial amputation during the pedagogical experiment

Parameters				Stages of the study							
				Before the pedagogical experiment				Before the pedagogical experiment			
				CG		MG		CG		MG	
				M (n=32)	W (n=11)	M (n=35)	W (n=8)	M (n=32)	W (n=11)	M (n=35)	W (n=8)
Statics	Foot angle (°)		R	14.78[1] ±2.84	13.82 ±3.83	13.77[2] ±2.80	15.63 ±3.72	13.16[1,4] ±2.66	12.82 ±2.23	11.71[2,4] ±2.00	12,25 ±2.25
			P	13.88[1,3] ±1.79	12,45 ±1,40	12,03[3] ±1,65	13,75 ±2,06	12,00[1] ±1,63	11,55 ±1,79	11,57 ±1.81	12,25 ±1.69
			D	3.47[1] ±0.99	4.45 ±0.50	3.51[2] ±1.10	4.13[2] ±1.16	4.22[1,4] ±1.18	4.18[4] ±1.29	1.74[2,4] ±0.67	1.25[2,4] ±0.56
Distribution of load (%)		R		42.72[1] ±1.49	44.09[1] ±0.86	43.69[2] ±1.87	41.63[2] ±3.13	44.03[1,4] ±1.79	45.36[1,4] ±1.06	45.77[2,4] ±1.32	46.75[2,4] ±0.81
		P		57.28[1] ±1.49	55.91[1] ±0.86	56.31[2] ±1.87	58.38[2] ±3.13	55.97[1,4] ±1.79	54.64[1,4] ±1.06	54.23[2,4] ±1.32	53.25[2,4] ±0.81
		R	Forward part	42.31[1] ±2.31	42.09[1] ±1.39	43.54[2] ±1.71	42.00[2] ±2.00	43.81[1,4] ±1.71	43.73[1,4] ±1.65	48.03[2,4] ±1.52	47.13[2,4] ±1.63
			Back part	57.69[1] ±2.31	57.91[1] ±1.39	56.46[2] ±1.71	58.00[2] ±2.00	56.19[1,4] ±1.71	56.27[1,4] ±1,65	51,97[2,4] ±1,52	52.88[2,4] ±1.63
		P	Forward part	49.38 ±1.26	50.09 ±0.68	49.60 ±0.96	49.38 ±0.72	49.84 ±0.95	50.27 ±0.84	49.74 ±0.98	49.63 ±0.63
			Back part	50.63 ±1.26	49.91 ±0.68	50.40 ±0.96	50.63 ±0.72	50.16 ±0.95	49.73 ±0.84	50.26 ±0.98	50.38 ±0.63
	Location of centre of body mass (mm)			25.94[1] ±5.74	24.09 ±6.83	24.37[2] ±6.76	23.25[2] ±6.44	20.75[1,4] ±3.48	19.82[4] ±4.35	14.51[2,4] ±2.93	14.88[2,4] ±2.88
Dynamics	Foot angle (°)		R	11.19[1] ±1.36	11.00 ±1.64	10.14 ±1.91	10.88 ±1.88	12.91[1,4] ±1.62	12.45 ±1.59	10.60[4] ±1.53	10.75 ±1.81
			P	11.00[1,3] ±1.69	9.45[2] ±1.60	9.00[3] ±1.72	9.13 ±1.16	12.09[1,4] ±1.61	10.64 ±1.54	10.57[2,4] ±1.36	10.74 ±1.31

		D	1.97[1,3] ±0.92	2.45[1] ±0,86	2.80[3] ±1.21	2.50[2] ±1.00	3.06[1,4] ±1.02	3.45[4] ±1.22	1.51[2,4] ±0.64	1.38[2,4] ±0.56
	Foot axis (°)	R	13.03 ±1.53	12.55 ±2.60	12.17 ±2.05	13.25 ±2.00	12.63[4] ±1.98	12.45 ±2.21	11.49[4] ±1.82	11.63 ±1.97
		P	12.13[3] ±1.75	10.91 ±1.21	10.29[3] ±1.37	11.00 ±1.75	11.84[4] ±1.59	11.09 ±1.39	10.57[4] ±1.56	10.88 ±1.16
		D	2.53[1] ±0.84	3.27 ±1.21	3.03[2] ±1.03	2.50 ±1.50	3.47[1,4] ±1.13	3.18[4] ±1.65	1.71[2,4] ±1.02	1.63[4] ±0.47
	Maximum load (g/cm)	R	1354.34 ±14.57[1]	1339.82 ±11.14[1]	1345.43 ±26.75[2]	1333.38 ±23.78[2]	1490.72 ±40.27[1,4]	1434.09 ±20.12[1,4]	1542.11 ±48.73[2,4]	1506.50 ±35.75[2,4]
		P	1980.53 ±38.31	1954.18 ±20.89[1]	2002,17 ±40,51	1946.18 ±38.97	1998.03 ±40.90	1997.82 ±35.26[1]	2002.69 ±50.36	1966.51 ±35.25
	Average load (g/cm)	R	585.00[1] ±11.13	561.45[1] ±11.04	578,14[2] ±15,59	570.50[2] ±13.88	622.56[1,4] ±16.15	583.36[1,4] ±13.31	651.83[2,4] ±24.39	623.88[2,4] ±31.81
		P	808.47[1] ±8.82	771,73[1] ±7.11	803,66 ±12,59	781.88 ±9.19	821.97[1] ±8.28	786.09[1] ±6.12	811.54 ±12.72	791.00 ±11.50
	Speed (mm/c)	R	286.53 ±14.63	281,27 ±18.48	280,94[2] ±13,94	278.25 ±15.94	290.56 ±12.22	280.09 ±14.64	291.23[2] ±12.62	291.00 ±12.25
		P	322.53 ±11.56	310.82 ±14.82	316,46 ±12,57	305.38 ±11.31	336.91[4] ±11.42	329.36 ±10.69	321.57[4] ±10.92	330.50 ±6.63

Notes: CG - control group; MG - main group; M - men; F - women; [1] – significance of differences in the indices of the control group before and after the pedagogical experiment ($p \leq 0.05$); [2] – significance of differences in the indices of the main group before and after the pedagogical experiment ($p \leq 0.05$); [3] – significance of differences in the indices of the control and main groups before the pedagogical experiment ($p \leq 0.05$); [4] – significance of differences in the indices of the control and main groups after the pedagogical experiment ($p \leq 0.05$). R – residual limb; P – preserved limb; D – difference in indicators of residual and preserved limb

The effectiveness of the author's approach to the development of a comprehensive program of physical therapy is also testified by such data.Intra-group changes ($p \leq 0.05$-0.01) in the parameters of the baropodometry among the representatives of the main groups were recorded as follows: the difference in the angle of the foot in the statics (by 50.43 % for men and by 69.73 % for women); load distribution between the extremities - up to 45.77 / 54.23 (males) and 46.75 / 53.25 (females) and parts (front and back) of the foot of the residual (prosthetic) limb to 48.03 / 51.97 (males) and 47.13 / 52.88 (females); location of body mass centre (by 40.46 % - men and by 36.00 % - women); the difference in the foot angle in dynamics (by 46.07 % - men and by 44.80 % - women); the difference in the foot axis (by 43.56 % -men and by 34.8 % - women); the maximum (by 14.65 % - men and by 12.98 % - women) and the average (by 12.63 % - men and by 9.30 % - women) load distribution on the feet supporting structures of the residual (prosthetic) limb. The advantage ($p \leq 0.05$-0.01) of the representatives of the main group of the subjects under study of the control group in the baropodometry parameters was as follows: the difference in the angle of the foot in the statics (by 58.77 % - men and by 70.38 % - women); location of body mass centre (by 30.07 % - men and by 24.92 % - women); the difference in the foot angle in dynamics (by 50.65 % -men and by 60.00 % - women); the difference in the foot axis (by 49.85 % - men and 48.74 % - women); maximum (by 3.48 % - men and by 5.02 % - women) and average (by4.66 % - men and by 6.86 % -women) load distribution on the feet supporting structures of the residual (prosthetic) limb.

Discussion

The growing social importance of conducting physical therapy measures for individuals with amputation impairments of diverse complexity dictates the requirement of paying attention to this issue. Effective prosthetics and training to use a prosthesis against the background of episodically substantiated approaches to physical therapy of persons with lower limbs amputation of at different stages, slows down solving the tasks of their medical and social, psychological therapy, their return to the normal lifestyle. The analysis of the data of scientific and methodological literature made it possible to identify the absence of modern scientifically grounded approaches to the physical therapy of persons with lower limb transtibial amputation at the stage of after hospital care. As an effect of a lower limb amputation, a number of complications can arise in various spheres of vital activity, in the functioning of the systems of the organism (cardiovascular, respiratory, nervous), and in the psychoemotional state, which, taking into consideration unsatisfactory level of substantiation of approaches to comprehensive rehabilitation of persons with such amputation impairments, necessitate the development of new and improvement of existing approaches to physical therapy of individuals with amputation stumps of the lower limb at the level of the shin to provide high-quality adaptation and compensatory reactions with the increasing number of such persons.

The process of physical therapy of persons with the lower limb transtibial amputation at the stage of

after hospital care should be ensured by a comprehensive approach to monitoring and recording both the basic indicators of qualitative and quantitative gait characteristics obtained on the basis of objective (baropodometry, chronometry) and subjective (manual-muscle testing, expert evaluation) research methods, assessment of the psycho-emotional state, physical preparedness and working capacity, traditional for rehabilitation practice methods of information gathering (anamnesis, somatoscopy, anthropometry, goniometry).

The key features of persons with the lower limb transtibial amputation, requiring physical therapy at the stage of after hospital care, are associated with poor physical fitness according to the indicators squats (7.1-9.5 times); bouncing on the preserved limb (22.9-29.4 times); flexion and extension of arms in the front lying support (11.8-20.1 times); sit-up from the back-lying position (5.3-11.7 times); indices of balance on the preserved leg and on the knee of the residual limb and their disproportion (15.68-22.30 s and 1.21-1.67 s, respectively); low parameters of gait (uniformity, rhythmicity, coordination of movements, value of body-rocking, smoothness, additional features), which were in the range from 1.79 to 2.55 points; unsatisfactory level of most indicators of baropodometry (angle of the foot, statics - 3.49-3.95°, dynamics - 2.40-2.47°, load distribution between the limbs 43.05-43.22 (residual) / 56.78-56.95 (preserved); the displacement of the projection of the centre of the body mass by 23.74-25.12 mm; the disproportion of the maximum and average load of the foot by 614-642 (g / cm) and 211-224 (g / cm), respectively).

The development of the comprehensive program of physical therapy for persons with the lower limb transtibial amputation at the stage of after hospital care is associated with the need in the formation of stable adaptive changes that can be caused only by conducting of a set of effective interventions of physical therapy. These include therapeutic physical culture, massage, the fundamentals of bandaging, combined developing exercises, gait training, exercises on training simulators. The theoretical substantiation of increasing the effectiveness of the implementation of these rehabilitation interventions allowed to propose the author's approach, which is contained in the use of training devices for body weight regulation, shifting the emphasis on gait training and massage orientation, means of active extension, using the Saarbrücken prosthesis and taking into account the principle of the maximum permissible activation of individuals involved in physical therapy.

Based on the study, the principle of the maximum permissible activation in physical therapy of individuals in early adulthood with the lower limb transtibial amputation after prosthetics for the implementation of the tasks of improving the use of the prosthesis and gait skills was scientifically substantiated, providing for the performing of exercises (implementation of other rehabilitation interventions), under which the maximum involvement of manifestations of morphofunctional properties occurs, enhancement of the musculo-articular activity and within a regional framework of the amputation impairment for the purpose of incentive to action, an increase in functioning and in general intensification of adaptive and compensatory impacts. In addition, scientific data have been obtained that characterize the general indices of the functional, motor and psychoemotional sphere of individuals with the lower limb transtibial amputation at the stage of after hospital care. Functional condition of individuals with the lower limb transtibial amputation is characterized by a generally low motor activity, ill-preparedness for walking on the prosthesis with a pronounced decrease in the strength and functional parameters of the muscular systems. The available low physical preparedness and working capacity, low qualitative characteristics of gait, inconsistency with the standards of baropodometry indices, which together was reflected on the psychoemotional state of individuals with lower limb transtibial amputation. Within the framework of the research, the program of physical therapy for young adults after the lower limb transtibial amputation at the stage of after hospital care was scientifically grounded.

Conclusions

1. The effectiveness of the author's comprehensive program of physical therapy for young adults after a lower limb transtibial amputation at the stage of after hospital care, was confirmed by intra-group changes in the main indicators, which for men are contained in a significant ($p \leq 0,05$-$0,01$) improvement in the results of the manual-muscular testing with achievement of five points in 74.3-91.4 % of cases; dynamometry of stump movements (for all types of movements) by 8.04-20.45 %; physical fitness (by all control exercises) by 23.65-60,98 %; expert estimates of gait characteristics (for all types) by 18.18-86.86 %; most baropodometry indicators - by 12.63-50.43 %. In women significant ($p \leq 0.05$-0.01) changes occurred in the results of manual-muscular testing (hip abduction) - by 87.5 %; dynamometry of stump movements (for all types of movements) by 12.83-26.62 %; physical fitness (for all control exercises) - by 25.28-142.08 %, expert estimates of gait characteristics (for all types) by 14.28-86.19 %; the majority of baropodometry indicators -by 9.30-69.73 %.

2. The advantages of the author's approach to the development of the comprehensive program of physical therapy for young adults after the lower limb transtibial amputation at the stage of after hospital care, are associated with a significantly higher efficacy ($p \leq 0.05$-0.01) compared to the usual program for such intergroup indicators: in men: dynamometry of stump movements (for all types of movements) – by 5.88-12.18 %; physical fitness (bouncing and balance on the knee of the residual limb) by 5.10 % and 67.25 % respectively; expert estimates of gait characteristics (uniformity, rhythmicity, value of body-rocking, smoothness) by 11.03-17.70 %; baropodometry (the difference in the angle of the foot in the static, the location of the centre of the body mass, the difference in the angle of the foot in the dynamics, the difference in the axis

of the foot, the maximum and average load on the support of the residual (prosthetic) limb) by 3.48-58.77 %; in women: dynamometry of stump movements (for all types of movements) by 8.71-17.03 %; physical fitness (balance on the knee of a residual limb) by 65.58 %; expert estimates of gait characteristics (uniformity, coordination of movements, value of body rocking, smoothness, additional features) by 8.39-32.68 %; baropodometry (the difference in the angle of the foot in the static, the location of the centre of the body mass, the difference in the angle of the foot in dynamics, the difference in the axis of the foot, the maximum and average load on the support of the residual (prosthetic) extremity) by 5.02-70.38 %.

Conflict of interests

The authors declare that there is no conflict of interests.

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