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Original Article

Shift of physical activity index for individuals with lower limb amputations as influenced by the comprehensive program of physical rehabilitation

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Abstract. In recent times observed is a significant rise in the number of individuals having the amputation defects of lower limbs. It is greatly associated with the increase of injury accidents, especially among people of working age affected by the motor vehicle collisions, industrial accidents, natural and industrial disasters, military actions as well as everyday routine injuries.. Aim. Determine the effectiveness of the author's comprehensive program of the physical rehabilitation of the mature individuals with the amputation defects of a lower limb in the tibia area. Organization. The participants were a group of 86 mature individuals with stumps of a lower limb in the tibia area. They were involved in the traditional (43 individuals) and the author's (43 individuals) programs of physical rehabilitation. The forming pedagogical experiment was conducted on the outpatient basis during 2010-2013, located on private and government companies producing orthopedic prosthesis. Results. We observed the gradual impact of the integrated author program of the physical rehabilitation for individuals with the lower limb amputation defects (in the tibia area). It has been revealed that the adequate amounts of the daily exercises physical activity causes the positive effect to the adaptation processes of the main group individuals. This was also manifested in the improvement of their emotional state, the level of the physical activity and the increasing time spent walking with the prosthesis, and as a result helped to solve many issues of social, labor rehabilitation and regain employment. The main gains of the suggested comprehensive program of rehabilitation appear in a better recovery of the muscle strength of both a stumped and a healthy limb (24,1−29,1% and 23,2−31,8% with $p \leq 0,05$); the results of motor tests 46,6−368,2% with $p \leq 0,05-0,01$); the aerobic efficiency – 15,0% of the baseline respectively.
Key Words: individuals, amputation, efficiency, authoring program.

Introduction

In recent times observed is a significant rise in the number of individuals having the amputation defects of lower limbs. It is greatly associated with the increase of injury accidents, especially among people of working age affected by the motor vehicle collisions, industrial accidents, natural and industrial disasters, military actions as well as everyday routine injuries (Albrccliisen, 1997; Baumgartner, 2002; Brsikin, 2016; Boychenko, 2002).

problem of individuals with the lower limb amputations defects is identified with the considerable locomotor dysfunctions. These are the factors that provoke the limitation of mobility and self-service, cause posture abnormalities, change the functional systems, modify metabolism processes, diminish the physical recourses and the physical activity endurance, and therefore restrain the biological processes.

The majority of individuals endowed with the lower limb amputation stumps suffer from the cardiovascular disorders, endocrine and neurology diseases, obesity etc. that lead to the drop in the compensatory and adaptive capacities of a human body and furthermore trouble the physical conditions (Lysovskyy, 2004; Evseev, 1998; Briskin, 2015)

The clinical trial data reveals that patients with lower limbs amputations are the most burdensome in regards to the rehabilitation, this involves varied aspects such as solving of medical, techno-rehabilitation, socio-philological and else tasks (Kannell, 1979; Kaszuba, 2003; Romanchyshyn, 2015) The world's as well as the Ukrainian prosthesis sphere lately has been advancing remarkably. The scientists and the specialists of prosthesis field are required to elaborate and apply the modern technology approach along with equipment in order to produce high quality orthopedic prosthesis products that ensure further rehabilitation of the disabled (Briskin, 2014; Kwolka, 2004)

Traditional theoretical assertion that main objective of the rehabilitation of individuals with amputation defects is the substitution of a full locomotion function (Rizzo, 1991) actually only limits itself to the prosthesis

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application and providing a user guide. However numerous scientists observed that impressive rehabilitation improvement can be achieved not only by means of high quality prosthesis but also by the level of adjustment ability of basic biological processes (Shahani, 1988; Shepard, 1990; Briskin, 2014; Vinogradov, 1988).

The integrated approach to the problem of the rehabilitation and functional recovery is absolutely essential given the emergence of a phantom pain. This specific long-lasting condition is attributed to a complex of the compensatory and pathological changes in a human body that occurs after the initial amputation, and requires serious aids of medico-social, labor and physical rehabilitation.

These facts prove that for the sake of the rehabilitation potential rise we need to develop a new and enhance the existing approaches to the physical rehabilitation of individuals with stumps of the lower limbs.

Aim of this research is to determine the effectiveness of the author's comprehensive program of the physical rehabilitation of the mature individuals with the amputation defects of a lower limb in the tibia area.

Methods & material

Theoretical analysis and generalization, pedagogical observation, pedagogical experiment, medico-biological methods (goniometry, manual muscle testing, tenzodynamometry, visual assessment of the walk, movement tests, aerobic capacity) and the method of mathematical statistics.

In order to test the suggested experimental program, elaborated for mature participants with amputation defects of a lower limb in tibia area, we suggested the following pedagogical experiment. The participants were a group of 86 mature individuals with stumps of a lower limb in the tibia area. They were involved in the traditional (43 individuals) and the author's (43 individuals) programs of physical rehabilitation. The forming pedagogical experiment was conducted on the outpatient basis during 2010-2013, located on private and government companies producing orthopedic prosthesis.

The comprehensive program of physical rehabilitation included the part of generally accepted components of the disabled rehabilitation (massage, training of strength and the endurance accumulation, motor coordination and application exercises) as well as the author's approach (training with the device that helps to learn walking with the limb prosthesis, that provides option of patient weight regulation, special exercises, the use of Saarbrucken prosthesis).

Results and Discussion

On basis of the suggested scientific article we noted the results of the main pedagogical experiment. In general the conducted research enabled the witnessing of a positive influence of physical rehabilitation means. We observed that acceptable amounts of everyday physical activities have positive impact on the adaptive capacities of the main group participants. This was manifested in the improvement of their emotional state, rise of the motor activity, the increase of an average time using the prosthesis. All of these aspects resolved the numerous issues of social and labor rehabilitation of the patients and thus helped them regain employment.

The anthropometric, stomatoscopic and goniometric researches that were held on the final stage of the rehabilitation, revealed the boost in not only the healthy limb muscle activity, but in the stump's muscles as well. The patients accumulated the arm and shoulder girdle muscle relief, their postures improved, the body mass index dropped on average to 8.4% in comparison to the starting rate.

For the majority of the main group patients the index of weight loss on average reached 2.5-4% after the first 10 days of the experiment, and towards the end of 21st day remained the same or returned to the initial level.

The most significant and solid indicator of the comprehensive rehabilitation program positive outcome was the emergence of controlled contractions of the truncated muscles. This effect was experienced by all of the participants of the main group.

The results of goniometry proved the improvement of the knee and hip joints mobility, as wells as the enlargement of the optimal range of motion while walking with the prosthesis under the influence of the special training and exercises. For all the group participants the extension capacity was totally restored allowing them fully load the stumped limb and regain the healthy posture.

The results of the myofascial manual therapy ensured the rise in movements of a stump and an injured limb. This brought about the increase of the test ratings, in most cases to 5 points. Meanwhile the ratings of the control group were poor and only observed for some representatives (52% of people).

The results of the tenzodynamometry of a stump and a healthy limb movements testified the presence of the certain positive dynamics of the parameters (table 1).

In the course of the suggested program observed was a significant increase in the muscle strength of both a stumped and a healthy limb – on average from 18.0% to 28.8% in comparison to the former rates. The biggest increase for a stumped limb was found in the stump contraction and withdrawal of the hip, whereas for a healthy limb in the contraction and withdrawal of the hip respectively.

Table *1*

The results of the tenzodynamometry of a stumped a healthy limb movements for the main group participants with a lower limb amputation defects in the tibia area (upon completion of a comprehensive program of the physical rehabilitation)

Type of motion	Muscle strength in the performance of motion (kg) n = 43							
	A stump of a tibia			Tibia			*Distinction, %	p*
	before	after	Increase, %	before	after	Increase, %		
Bending	26,6 ±2,3	34,2 ±1,6	28,6	35,8 ±2,2	44,5 ±3,1	23,2	30,1	<0,05
Straightening	34,4 ±5,1	42,7 ±2,8	24,1	47,7 ±4,2	56,3 ±2,7	18,0	31,8	<0,05
Contraction of the hip	30,4 ±2,1	38,4 ±4,2	26,3	37,3 ±4,9	47,3 ±3,6	26,8	23,2	<0,05
Withdrawal of the hip	24,4 ±2,9	31,5 ±2,1	29,1	31,9 ±2,7	41,1 ±2,2	28,8	30,5	<0,05

Remarks:

* − the distinctions between indexes of a tibia stump and a healthy tibia upon completion of the comprehensive rehabilitation program for the individuals with the amputation defects of a lower limb in the tibia area;

p* − the distinctions between indexes of a tibia stump and a tibia.

The biggest increase of the muscle strength indexes was observed in the middle of the physical rehabilitation final stage. We also recorded the increase in used capacity on cyclical simulators.

Likewise the positive results were noticed in the increase of the muscle strength indexes of the control group. (table 2).

Our pedagogical observation showed that the control group increase of muscle strength indexes differentiated from those in the main group both in quality and quantity, and amounted to 15.4% of the starting rates.

Table 2

The results of the tenzodynamometry of the stumped and the healthy limb movements for the control group participants with a lower limb amputation defects in the tibia area (upon completion of a comprehensive program of the physical rehabilitation)

Type of motion	Muscle strength in the performance of motion (kg), n = 43							
	A stump of a tibia			Tibia			* Distinction, %	p*
	Before	After	Increase, %	Before	After	Increase, %		
Bending	26,6 ±2,3	27,2 ±2,6	2,3	35,8 ±2,2	41,3 ±5,1	15,4	55,9	≤0,05
Straightening	34,4 ±5,1	36,7 ±1,5	6,7	47,7 ±4,2	52,1 ±1,8	9,2	41,9	≤0,05
Contraction of the hip	30,4 ±2,1	33,2 ±5,2	9,2	37,3 ±4,9	42,1 ±2,5	12,6	26,8	≤0,05
Withdrawal of the hip	24,4 ±2,9	27,5 ±4,1	12,7	31,9 ±2,7	37,1 ±1,1	14,0	34,9	≤0,05

Remarks:

* − the distinctions between indexes of a tibia stump and a healthy tibia upon completion of the comprehensive rehabilitation program for individuals with amputation defects of a lower limb in a tibia area;

p* − the distinctions between indexes the tibia stump and the tibia.

The correlation of the stumped and the healthy limb indexes of the control group dropped more than in twice which brought the functionality of a stumped limb closer to a healthy one. While in control group these improvements were less noticeable.

The results of the strength of muscle contractions research demonstrate that using this program's approach we were able to solve the problem of restoring the locomotor power components for both a stumped limb and a healthy one of the main group participants.

The motor tests suggested for the evaluation of the healthy limb muscles' function prove a significant increase of the healthy limb muscles function quality, in some cases up to 368.2% (body lift from the lying position, table 3).

Table 3

The comparative analysis of the motor tests for the main and the control groups of patients with the defects of the lower limb amputation in the tibia area
(upon completion of the comprehensive program of physical rehabilitation)

Type of motion	Main group, n = 43				Control group, n=43				p*
	Before	After	Increase, %	p	before	After	increase, %	p	
Squatting	8,1 ±2,4	26,1 ±3,1	222,2	≤0,01	8,0 ±2,0	14,3 ±2,1	78,7	≤0,05	45,2 ≤0,05
Jumps	26,2 ±2,1	38,4 ±2,1	46,6	≤0,05	26,0 ±2,4	29,1 ±1,4	11,9	≤0,05	24,2 ≤0,05
Push ups	14,3 ±3,1	28,2 ±1,8	97,2	≤0,05	14,6 ±2,8	21,1 ±3,2	44,5	≤0,05	25,2 ≤0,05
Body lift from the lying position	8,2 ±2,4	38,4 ±2,1	368,2	≤0,01	8,7 ±1,6	10,1 ±2,1	16,1	≤0,05	73,7 ≤0,05

Remarks: p* − indexes (%) and the accuracy of the differences between stats data of the individuals from the main and the control groups of participants with the defects of a lower limb amputation in the tibia area, recorded upon completion of the rehabilitation program.

While testing the functionality of the arms we have also observed that the increase of the index rates almost doubled. The testing of the trunk muscles' function revealed the most remarkable achievements – in comparison to the starting rates they grew in 3 times. We associated this notion with the decrease of the patients' weight and the accumulation of the muscle strength.

The rise of the tested main muscles indexes for control group participants was not as intense, and averaged from 11.9% to 78.7%.

Thus the research of the muscle groups' power and the functional indexes for participants of the locomotion reflect the high efficiency of the suggested comprehensive program for the physical rehabilitation of the individuals of a mature age with stumps of the middle third of the tibia.

It is worth noting that the long-term effect of the physical rehabilitation program not only increases the power components but also improves the motor coordination and tends to be easily performed by the participants in the way of various exercises and games. It all proves the development of the muscle coordination and the interaction which can be determined as the manifestation of the muscular fitness.

The full restorative influence of the physical rehabilitation program for physical performance was displayed by the final results of the Maximum Oxygen Uptake test (using the veloergomerty device).

Even though at the final stage of the physical rehabilitation the patients were provided with the common (foot) veloergometry, the comparative analysis of MOU was held on the basis of the manual mode pedaling in order to maintain the standard approach of the pedagogical experiment. (Table 4)

Table 4

Estimated rates of the main and the control groups' oxygen uptake during the veloergometry test

Rated MOU (l/min)	MOU index (l/min),	
	Main group, n = 43	Control group, n = 43
Output data	2,06 ±0,04	2,01 ±0,08
Final data	2,37 ±0,02	2,14 ±0,02
p	≤0,05	>0,05
Distinction, %	15,0	6,5

According to the results of this research in the main group we observed a remarkable increase of the MOU, on average by 15.0% compared to the output data. It is worth mentioning that the load of 160W was executed by all of the participants.

Whereas in the control group the test of the MOU index was conducted simultaneously, but the distinction of the parameters in comparison to output data were only noted as 0.07-0.09 l/min and thus cannot be reliable (p > 0,05).

The important testing parameters of the individuals after a course of the physical rehabilitation were the Heart Rate Index and the blood pressure – both measured during the training session and at rest.

The fig. 5 shows average graphic HRI response during the veloergometry test.

As seen in the graph after the course of rehabilitation a remarkable improvement of cardio-respiratory system took place, this was manifested in a higher HRI (average 162 beats/min) under load of 160W.

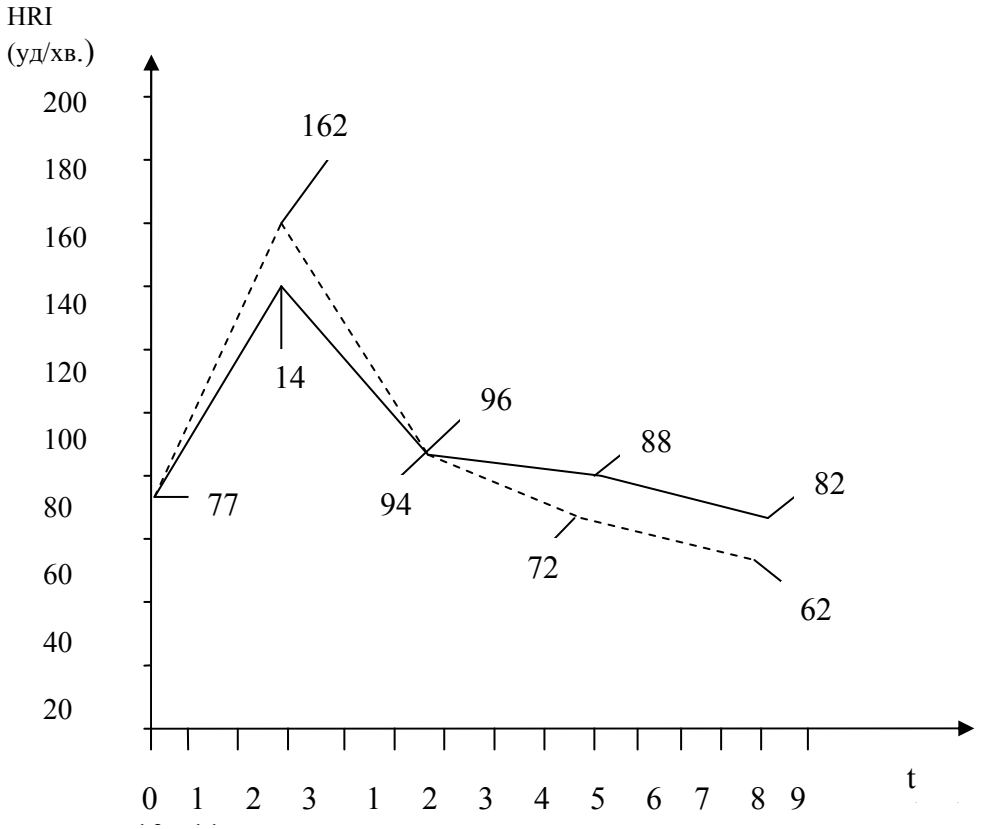

Fig. 5 The graph of HRI reaction for veloergometry test taken before and after the course of the physical rehabilitation (average values):
_____ − (120W), HRI output data;
- - - - - - − (160W), HRI after the comprehensive program of the physical rehabilitation.of HRI

Before the training the average HRI was 142 beats/min. with a maximum load of 120W. The important indicator of the fitness in this example is the recovery time after the exercise.

While at the first stage the recovery of HRI after the exercise lasted up to 10 min upon completion of the physical rehabilitation program the recovery period was reduced to 6 min and the recovery index even outwent the output data.

Thus while conducting the research of HRI with the load we observed the increasing functionality of the cardio-respiratory system before the training activities which manifested in a linear increase of a heart rate and the reduction of the recovery time (in twice) compared to the recovery time before participating in the physical rehabilitation program.

The test of the blood pressure with load after training program also indicated the physical response of the blood pressure that does not exceed the threshold level in all of the main group participants. However the return of the blood pressure to the baseline was slower in comparison to the recovery of the heart rate.

The results of the physical performance test, based on calculated data of MOU during veloergometric exercise, showed the evidence of this parameter improvement as a result of the comprehensive physical rehabilitation program impact.

The adequate physical response of the HRI and the blood pressure to the loading increase during velorgometic training as well as the reduction of the HRI recovery time to 6 min indicated the lift of the general level of fitness for all the patients of the main group trained on the basis of the suggested program.

Conclusions

We observed the gradual impact of the integrated author program of the physical rehabilitation for individuals with the lower limb amputation defects (in the tibia area). It has been revealed that the adequate amounts of the daily exercises physical activity causes the positive effect to the adaptation processes of the main group individuals.

This was also manifested in the improvement of their emotional state, the level of the physical activity

and the increasing time spent walking with the prosthesis, and as a result helped to solve many issues of social, labor rehabilitation and regain employment.

The main gains of the suggested comprehensive program of rehabilitation appear in a better recovery of the muscle strength of both a stumped and a healthy limb (24,1−29,1% and 23,2−31,8% with $p \leq 0,05$); the results of motor tests 46,6−368,2% with $p \leq 0,05-0,01$); the aerobic efficiency – 15,0% of the baseline respectively.

Prospects of further research: assumed is the further study of the implementations of the comprehensive program of the physical rehabilitation for individuals with the lower limb amputation defects in the tibia area (pshyco-emotional and motor features)/

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