RESULTS OF IMPLEMENTATION OF SOCIAL REHABILITATION TECHNOLOGIES FOR PEOPLE WITH LOWER EXTREMITY DISEASES / INJURIES

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Abstract

People with lower extremity diseases/injuries have limited mobility that affects their participation in socio-economic processes, including integration into the labour market. It is one of the risk groups that are exposed to the risk of social exclusion, and provision of the quality of their life requires the development of protection mechanisms. It is necessary to provide social rehabilitation and support services to facilitate their return to labour market and their involvement in all social activities alike other members of society.

The article focuses on the provision of social rehabilitation services through innovative BIODEX SYSTEM 4, BIOSWAY and Vibro-massage facilities. The results of a linear research have been analysed and a description of case studies has been given.

Key words: *social rehabilitation, lower extremity diseases/injuries, neuromuscular testing and training, balance training and testing, vibro-massage.*

Introduction

21st century will go down into history with the change of view about people with disabilities – from a medical model, which dealt just with a human body and its disorders, to a social model, which perceives every person as a value, regardless of their disabilities. Since there are changes in society's attitude towards people with disabilities, they are able to obtain a good education and work. If this resource is not used, the society will experience losses (Šķestere, Anča, et al., 2008).

Regardless of the statistics on the growing number of disabled people in the world (World Facts and Statistics, 2013) and the change of society's attitude, neither race nor ethnicity causes as many obstacles to career development as it is created by special needs (Mouls, 2003). People with various functional disorders often experience unfair attitude at work (Disability facts and figures, 2013). A great number of people face these obstacles, because approximately 650 million people in the world are disabled or have functional disorders, and about 386 million of them are of working age (World Facts and Statistics, 2013). The statistics of different countries show the increasing number of people with disabilities / persons with functional disorders: for example, in Australia the disability level is 18.5 % of the population

of working age (Advancing the equitable inclusion, 2013), the USA – 12.1%, the UK – 16% (Disability facts and figures, 2013)), one out of eight working-age people in European Union is either a person with a disability or chronic disease, and 78 % of them are outside the labour market (Živitere, 2008).

In Latvia situation is exacerbated by the situation in labour market. In June 2013 there were 94,757 unemployed registered in State Employment Agency. The registered unemployment rate in the country at the end of June 2013 was 9.6%. One out of ten (10.1%) unemployed is the person with disabilities. There is no data about persons with potential disabilities.

World Health Organization (WHO) states that every person may experience temporary or permanent disabilities in their lifetime (World Report on Disability, 2011). Everything mentioned above points to the need to create conditions, which would favour people's with functional disorders involvement in the labour market, because it positively affects a person's self-esteem on their physical work capacity (Chorus, Miedema, Boonen, & Van der Linden, 2003). If it is not provided the society itself creates economic, social and psychological problems, but people with disabilities in case of unemployment have limited or no opportunities to build social and professional relationships (Hernandez, Cometa, Velcoff, Rosen, Schober & Luna, 2007).

To favour persons' with disabilities caused by disease or injury return to work, there were organized rehabilitation measures using BOIDEX SYSTEM 4, BIOSWAY and local Vibro-massage facilities within the project "Designing a Model Geared Towards Participation of People at Risk Social Groups in the Labour Market" (MODPART) "LLIV-223. The paper presents research results.

Methodology and organization of the research

The research was carried out by five researchers, including a physician-rehabilitator and a professional in vibromassage.

There were 25 people involved in MODPART project: 12 men and 13 women, who suffer from lower extremity disease / problems, which belong to 14 different groups of diseases according to disease classification. Despite the diversity of diagnoses, the main problem in many cases is similar, for example, the problem in 5 cases was identified as the joint contracture, in 11 cases – pain syndrome, in 5 cases – instability of the joint after injury, and in 6 cases – ligament disorder.

To implement the project a linear model was selected that provides the acquisition of initial data, theoretically based rehabilitation activities, applying the facilities mentioned above, and response evaluation of one of the research groups in a certain period of time (see Figure 1).

According to the initial examination and a physician-rehabilitator's recommendations individual programs of designated physiotherapy with BIODEX 4 were designed, which prescribed the training sessions of lower limb muscles, balance training with BIOSWAY equipment and massage sessions with local Vibro-massage equipment, exposing on the lower extremity joints and muscles and promoting blood flow to the muscles. To analyze the effectiveness of measures a testing was carried out at the beginning and at the end of the research. The obtained data were coded and processed in SPSS program.
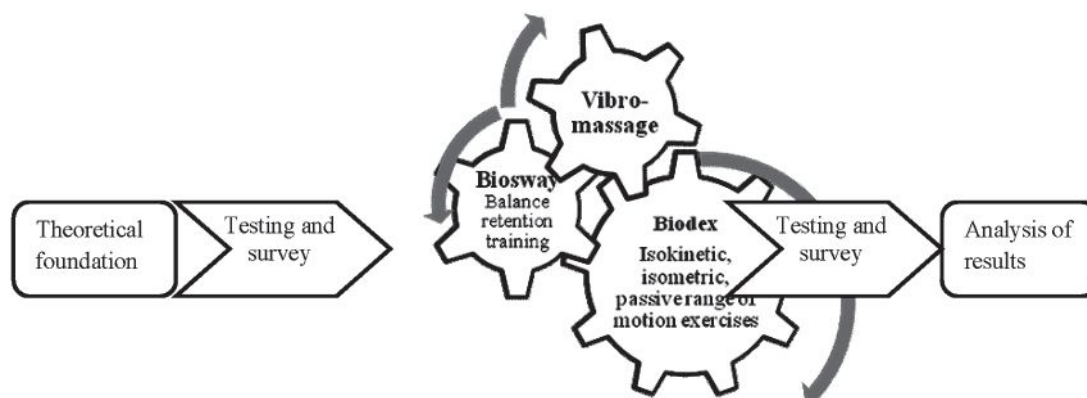
Figure 1. The scheme of linear experiment

Results of the research

In order to obtain the information about the participants' self-rated health a questionnaire was conducted, which included the participating researchers' questions and internationally recognized EQ-5D-5L questionnaire. The results obtained in the survey were coded and processed in the program SPSS 20.0.

Comparing respondents' answers to the questions of internationally recognized questionnaire EQ5-5D-5L at the beginning and at the end of the research, it was concluded that in most cases the problems have not disappeared, but they have decreased (see Table 1).

Table 1. Effectiveness of rehabilitation measures (results of Wilcoxon Signed Rang Test)

Position	Negative Ranks	Positive Ranks	Ties	Asymp.Sig.(p)
Movement abilities	0	15	10	0.000
Self-care	0	9	16	0.005
Daily activities	0	10	15	0.002
Pain	1	15	9	0.001
Anxiety/depression	1	12	12	0.003
Health self-assessment %	2	17	6	0.003

In order to better understand the results of the project the respondents assessed the intensity of problems related. The results are summarized in Table 2.

Table 2. The comparison of intensity of the problem at the beginning and at the end of the linear experiment (Wilcoxon test)

Activity	Negative Ranks	Positive Ranks	Ties	Asymp.Sig.(p)
Daily walking	1	9	15	0.013
Long distance walking	1	9	15	0.010
Short distance walking	1	7	17	0.087
Running	2	6	17	0.084
Climbing several storeys	1	12	12	0.003
Climbing one storey	0	10	15	0.004
Bending	3	12	10	0.010
Getting on knees	2	10	13	0.015
Bending forward	3	15	7	0.004

				Table 2 (end)
Lifting different objects	0	7	18	0.011
Sitting for a longer time	2	12	11	0.007
Standing for a longer time	1	12	12	0.003
Carrying shopping bags	1	13	11	0.002
Cleaning work	0	8	17	0.007
Self-care	1	8	16	0.020

Using BIODEX SYSTEM 4 technology, testing was done in the same way as it was done at the beginning of the research at 60 deg/sec, 80 deg/sec and 300 deg/sec, focusing on parameters such as peak torque (extension), total work (extension), peak torque (flexion), and total work (flexion). Testing results obtained by the help of devices using Wilcoxon test indicate a positive dynamics (see Table 3).

Table 3. BIODEX SYSTEM 4 testing results (Wilcoxon test)

Tests	Negative Ranks	Positive Ranks	Ties	Asymp. Sig. (p)
peak torque (extension)				
60 deg/sec	0	14	1	0.001
180 deg/sec	0	15	0	0.001
300 deg/sec	0	14	1	0.001
total work (extension)				
60 deg/sec	0	12	3	0.002
180 deg/sec	0	15	0	0.001
300 deg/sec	0	15	0	0.001
peak torque (flexion)				
60 deg/sec	0	11	4	0.003
180 deg/sec	0	7	8	0.018
300 deg/sec	0	4	11	0.059
total work (flexion)				
60 deg/sec	0	8	7	0.010
180 deg/sec	0	7	8	0.018
300 deg/sec	1	8	6	0.013

The results show that with the exception of one position (total work (flexion) at 300 deg/sec) there is a positive dynamics. This suggests that the selected training modes increase patients' lower extremity muscle strength, facilitate the improvement of their health, wherewith a faster return to work.

The results of testing with the equipment BIOSWAY show that after training session the balance control has improved: 12 patients' result is above 65% (in the first testing only one patient showed such a good result). The results of Wilcoxon test give the evidence of balance control improvement dynamics (see Table 4).

The positive dynamics is the result of the rehabilitation measures applying local Vibro-massage device, because vibromassage locally accelerates blood flow, enhancing blood flow to certain parts of the body, excites the nerves that have lost their operational capacity, and vice versa. Transient vibration applied every day can increase muscle strength and their capacity and can hasten the healing process (Ciematnieks, 2011).

The results show that well-balanced and complex application of all devices purchased in MODPART project facilitates social rehabilitation process and helps people with lower extremity injuries or disease return to work.

The efficiency and effectiveness of a complex application of BIODEX SYSTEM 4, BIOSWAY and Vibro-massage devices are proved by the data obtained in the result of retesting with BIODEX SYSTEM 4 after the rehabilitation session. It showed significant differences in peak torque (flexion) at 60 deg/sec (p = 0.043), total work (flexion) at 60 deg/sec (p = 0.042), peak torque (extension) at 180 deg/sec (p = 0.014) and total work (flexion) at 300 deg/sec (p = 0.049). In all cases the higher mean rank could be observed when all three devices – BIODEX 4, BIOSWAY and Vibro-massage device were applied, lower results appeared when two devices were applied – BIODEX 4 and BIOSWAY technology, but even lower results were achieved when BIODEX 4 and Vibro-massage device were used.

Table 4. Balance control improvement dynamics

Tests	Negative Ranks	Positive Ranks	Ties	Asymp. Sig.(p)
Limits of stability testing				
Total result	0	17	5	0.000
Anterior movement	1	18	3	0.000
Posterior movement	2	13	7	0.006
Movement to the right	3	13	7	0.008
Movement to the left	3	17	2	0.008
Postural stability testing				
Total deviation	1	13	8	0.002
Deviation forward and backward	0	12	10	0.001
Deviation to the right and to the left	1	9	12	0.013
Test of sensory integration of balance				
Firm surface, eyes open	2	13	12	0.003
Firm surface, eyes closed	3	17	2	0.013
Foam surface, eyes open	2	14	6	0.008
Foam surface, eyes closed	3	15	4	0.011

To better understand how the rehabilitation measures were organized, we offer to look at a detailed description of one patient's activities.

Patient V-EL, age – 32.

Doctor's diagnosis: Right leg knee joint cross ligament rupture (August 10, 2012). The injury was sustained while doing sports, during football training. Autotransplantation was carried out on October 3, 2012. Prior to the participation in MODPART project the patient V-EL had an initial rehabilitation course (20 sessions).

Before V-EL's participzation in the project, during medical examination a physician-rehabilitator identified the patient's major problems: pain, distress symptoms, instability, and muscle weakness. These problems are also identified in initial testing using BIODEX SYSTEM 4 and BIOSWAY equipment.

After initial testing with BIODEX SYSTEM 4 equipment in a three-speed (60^0/s-180^0/s-300^0/s) isokinetic mode it was discovered that there was a significant muscle strength parameter deficit in the traumatized leg. The extensors of the traumatized leg (the right one) were 40 % weaker than the ones of the healthy leg. There were no significant differences in flexors, i.e. in the range of 13%. Analyzing the muscle strength parameters of the healthy leg (the left

one), it was determined that hamstring muscles are significantly weaker than quadriceps. Poor hamstring development is an important risk factor for possible knee injuries because they are not able to effectively slow down the movement of the lower leg caused by the strength of the quadriceps muscles. This may be the reason for muscle sprains and ligament injuries. The peak torque deficit in traumatized leg has significantly influenced other parameters in the test, i.e. capacity and total work results of the right leg were significantly lower (approx. 35 to 40%).

The initial testing was carried out using BIOSWAY equipment. The results point to balance disorders: the results of Postural stability test show that the total deviation from the centre is 0.6 (standard deviation is 0.1-0.2), in Limits of stability test problems in control of the centre of gravity were identified. Test of sensory integration of balance indicates that sway index does not meet the standard in all four positions (see "Technology for balance testing and training, its implementation methodology".)

A physician-rehabilitator set rehabilitation goals for the patient V- EL: to strengthen the muscles of the right leg, to strengthen hamstring muscle group of the left leg, to stabilize the knee joint of the right leg, to improve trophics and coordination. To achieve the goals a rehabilitator prescribed a training session using BIODEX SYSTEM 4, BIOSWAY and local Vibro-massage facilities, and elaborated an individual rehabilitation program. The course of rehabilitation procedures carried out in the project was recorded (see Table 5).

Before training with BIODEX SYSTEM 4 equipment a general warm-up workout was done on an indoor stationary bike (5 min.) at a moderate pace and leg muscle stretching exercises (2 min.).

Right leg exercise mode:

An isokinetic Biofeedback mode up to 75% fatigue level, with gradual increase and reduction in speed. Since the patient has already had initial rehabilitation and there was no limitation of movements, a fast motion mode was chosen, which is functionally more appropriate.

$180\,^0/s – 210^0/s – 240^0/s – 270^0/s – 300^0/s – 300^0/s – 270^0/s – 240^0/s – 210^0/s – 180^0/s$

The rest between exercises is 45 seconds or subjectively to normal breathing rhythm.

Peak torque – Nm, total work – J and coefficient of variation (Coeff. of var.%) were recorded in the exercise protocol.

Left leg hamstring muscle development program was divided into two phases. In the first phase an isokinetic Biofeedback mode up to 75% fatigue level was also selected, with a gradual increase and reduction in speed, but the velocity of up and down movements was different. In order to put an emphasis on hamstring muscle work upward movement was faster, which is done with less torque, but the movement down was slower providing the opportunity to realize a larger effort.

Left leg exercise mode Move Up:

$180^0/s – 210^0/s – 240^0/s – 270^0/s – 300^0/s – 300^0/s – 270^0/s – 240^0/s – 210^0/s – 180^0/s$

Left leg exercise mode Move Down:

$60\,^0/s – 90^0/s – 120^0/s – 150^0/s – 180^0/s – 180^0/s – 150^0/s – 120^0/s – 90^0/s – 60^0/s$

Rest between sets – 45 seconds or subjectively to normal breathing rhythm.

Assessing the results of the first five sessions, it was concluded that initially with the improvement of torque results the amount of total work decreased, but in the fifth session it increased again because of the reduction of torque parameters. Therefore, after obtaining the interim testing results, it was decided to change the kind of activities and to include eccentric muscle resistance mode.

Training program was supplemented with the following parameters:

flexion – $120^0/s$ – isokinetic mode;

Table 5. Patient's V-EL individual rehabilitation program

	Mode	Times	Date (minutes)
Biodex 4	Initial testing	1	13.05.13. – 60 min.
	Warming up	110.	
	Left leg knee. Isokinetic load flexors/extensors 180^0/s/60^0/s – 210^0/90^0/s – 240^0/120^0/s – 270^0/150^0/s – 300^0/180^0/s 300^0/180^0/s – 270^0/150^0/s – 240^0/120^0/s – 210^0/90^0/s – 180^0/s/60^0/s		14.05.13. – 60 min. 17.05.13. – 60 min. 20.05.13. – 60 min. 22.05.13. – 60 min.
	Right leg knee. Isokinetic load flexors/extensors 180^0/s – 210^0 – 240^0 – 270^0 – 300^0 – 300^0 – 270^0 – 240^0 – 210^0 – 180^0/s		24.05.13. – 60 min. 27.05.13. – 60 min. 29.05.13. – 60 min. 31.05.13. – 60 min. 03.06.13. – 60 min. 05.06.13. – 60 min.
	Final testing	1	07.06.13. – 60 min.
Biosway	Initial testing (assessment of functional condition, rehabilitation program)	1	13.05.13. – 60 min.
	Exercises (on a firm platform on PST, WST, WBT, MCT, RCT mode; on a foam platform in PST, WST, MCT mode)	110	13.05.13. – 25 min. 14.05.13. – 35 min. 20.05.13. – 35 min. 24.05.13. – 35 min. 27.05.13. – 35 min. 31.05.13. – 35.min. 03.06.13. – 35 min. 07.06.13. – 35 min. 20.06.13. – 35 min. 27.06.13. – 35 min.
	Final testing	1	27.05.13. – 20 min.
Vibro-massage	8 procedures		13.05.13. – 35 min 03.06.13. – 35 min. 04.06.13. – 35 min. 21.06.13. – 35 min. 25.06.13. – 40 min. 26.06.13. – 40 min. 27.06.13. – 40 min. 28.06.13. – 40 min.

extension 10^0/s – eccentric resistance with effort to 65Mm;
training time – 10 minutes;
number of sets – 6.

Using BIOSWAY equipment, the patient V-EL was offered a workout program that included Postural stability training, Limits of Stability Training, Weight Shift Training, Maze Control Training; Random Control training and Percent weight Bearing Training.

Applying vibro-massage device, the following procedure modes were used:

• vibromassage with a conic vibratod; 4 procedures were carried out, in the first two procedures the vibration level was 60 Hz, in the next two – 80 Hz .

• vibromassage with an iron vibratod; in the first two procedures the vibration level was 100 Hz, in the next two 100 Hz .

At the end of vibromassage session, basing on the interviews with the patient V-EL, it was found that he felt better, the pain had decreased, a range of motion in the joint had improved, muscle and ligament tension had decreased, leg muscles had become stronger, and muscle endurance had increased. Survey results showed a positive dynamics, too. If at the beginning of the research the patient V-EL assessed his current state of health by 65 %, the score at the end of the project amounted to 80%. Furthermore, the problems the patient V-EL faced, when he had to get on his knees or to carry the shopping bag, have reduced.

Undeniably, it is the result of using all three devices purchased in MODPART project. The results obtained in the final testing with BIODEX SYSTEM 4 and BIOSWAY equipment prove that the patient's V-EL state of health has improved.

Obtaining the results of final testing with BIODEX SYSTEM 4 equipment it can be concluded that there was a significant improvement in the results compared to the initial testing results (see Table 6).

Table 6. Initial and final testing results of isokinetic mode

Velocity Motion mode: extension		$60^0/s$			$180^0/s$			$300^0/s$		
Testing date		**13.05.**	**07.06.**	**%**	**13.05.**	**07.06.**	**%**	**13.05.**	**07.06.**	**%**
Torque	Nm	246.3	238.0	-3.4	157.1	165.6	5.4	122.1	118.4	-3
Coefficient of variation	%	18.4	6.8		7.1	10.5		12.9	13.6	
Total work	J	1120.1	1471.5	31.4	1837	2118	15.2	2056	2230	8.4
Max. work in one set	J	253.3	327.2	29.2	206	244	18.5	164.2	182.5	11.2
Velocity Motion mode: flexion		$60^0/s$			$180^0/s$			$300^0/s$		
Testing date		**13.05.**	**07.06.**	**%**	**13.05.**	**07.06.**	**%**	**13.05.**	**07.06.**	**%**
Torque	Nm	102.0	120.5	18.1	71.7	95.2	33.3	72.8	75	3
Coefficient of variation	%	13.6	2.4		6.2	8.8		27	15	
Total work	J	524.4	877.1	67.3	882	1289	46.1	1037	1335	28.6
Max. work in one set	J	122.3	186.3	52.4	96.2	141.8	47.5	85	111.9	31.6
Agonist/antagonist ratio	%	41.4	50.6	18.2	45.5	57.5	20.9	59.6	63.3	5.5

In the Table 6 we can see that the torque results of quadriceps after 11 sessions have not significantly changed, but the level of muscle performance has significantly improved (8.4%–31.4%). Hamstring muscle results have significantly improved in all parameters and at all speed modes. Peak torque has increased by an average of 18% (3%–33.3%), muscle power improved by nearly half (28.6%–67.3%), and the maximum effort per set has increased by 44% (31.6%–52.4%).

The results of testing with BIOSWAY equipment show positive dynamics, too. Postural stability test (see Table 7) indicates the patient V-EL's ability to maintain the increase of balance centre, because deviation from the centre has reduced (the lower the score, the better).

Table 7. Patient V-EL's results in Postural stability test

	Initial testing	Final testing
Total	0.6	0.4
Forward - backward	0.5	0.4
To the right – to the left	0.2	0.1

Patient V-EL carried out Limits of Stability Test in moderate mode. The results of the test (see Table 8) show a positive dynamics.

Table 8. Patient V-EL's results in Limits of stability test

	Initial testing	Final testing
Total	36	75
Forward	34	64
Backward	69	76
To the right	34	60
To the left	27	40

In the first or initial testing the results were below the acceptable range (score was less than 65 points). Second or final testing results show that the patient V-EL's dynamic balance has improved by 75%.

The patient V-EL's results in Test of sensory integration of balance (see Table 9) show that sway index has improved in all 4 positions. It has become smaller, indicating a stable dynamics and the patient's sway reduction.

Table 9. Patients V-EL's results in Test of sensory integration of balance

	In the beginning	In the end	Standard
Eyes open, firm surface	0.50	0.36	0.21-0.48
Eyes closed, firm surface	1.53	0.71	0.48-0.99
Eyes open, foam surface	0.70	0.54	0.38-0.71
Eyes closed, foam surface	2.19	1.98	1.07-2.22

The obtained results confirm the compliance of the applied methodology with the tasks set before the project. In the result of training session a significant improvement can be observed in both hamstring muscles and quadriceps of the traumatized leg. While in the other leg the agonist and antagonist muscle group ratio has significantly improved, which reduces the risk of injury. Static and dynamic balance has improved wherewith the patient feels much better and he has returned to active mode, i.e. to the labour market.

Conclusions

1. The statistics on the increasing number of disabled people in the world and Latvia define the need to create conditions for social rehabilitation and support services thus facilitating people's with disabilities integration into labour market and involvement in social activities alike other members of society.

2. The analysis of results obtained in linear research reveals a positive dynamics and significant changes: lower extremities muscle strength increases, balance control and feeling of participating people with lower extremity injuries/diseases improve.

3. The results of analysis obtained in linear research of MODPART project indicate that well-balanced and complex use of innovative BIODEX SYSTEM 4, BIOSWAY and Vibro-massage equipment improves people's with functional disorders state of health, thus favouring their involvement in social activities and return to the labour market.

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