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Centre for Persons with
Acquired Brain Injury Maribor

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NEW FORM OF PHYSICAL THERAPY **PROGRESSIVE REHABILITATION OF NEUROMOTOR DYSFUNCTION**

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ABSTRACT

The paper presents a new approach to neuromuscular and motor rehabilitation. It has been successfully implemented into rehabilitation programs at the rehabilitation centre NAPREJ, where long-term psychosocial rehabilitation for persons with ABI is carried out. In a few steps, we will present certain new possibilities of progressive rehabilitation with the use of a training device called PRO SKI SIMULATOR.

We will explain how it is possible with PRO SKI medical training progressively and positively affect motor as well as cognitive skills of people with neuro motor dysfunction resulting from a stroke or head trauma. We will emphasize in which segments of rehabilitation and healthy lifestyle PRO SKI training is successfully used.

We will present the results of the program based on the assessment of specific, short period training of persons with ABI with data on their physical condition before and after the implementation of the program.

Keywords: medical fitness, neuro-rehabilitation, progressive approach, motor and cognitive skills, acquired brain injury, Pro Ski, Centre Naprej

1 INTRODUCTION

Acquired brain injury (ABI) is a brain disorder that occurs after birth and not the result of genetic, degenerative processes such as aging, accident or childbirth. Long-term consequences of brain injury are difficult to predict. They differ from person to person and range from mild to very serious.

To ensure the quality of life after a serious brain injury it is necessary to provide comprehensive care, perform continuity measures and procedures from the moment of injury throughout the acute period of a comprehensive treatment in the post-acute phase. In case of long-term consequences on an individual's life we can talk about a long-term need for psychosocial support or long-term psychosocial rehabilitation. Persons who have suffered severe brain damage commonly needed after the completion of primary medical rehabilitation professional assistance and advice as well as integration into a stimulating environment that allows them to make progress, training and support in creating new life goals.

Among numerous consequences of traumatic brain injury (TBI) is the lack of balance. Between 30% and 65% of people with TBI suffer from dizziness and disequilibrium (lack of balance while sitting or standing) at some point in their recovery. Dizziness includes symptoms such as lightheadedness, vertigo (the sensation that you or your surrounding is moving), and imbalance.

Balance is one of those vital functions we often take for granted, unless we suddenly find that our balance is not as it used to be. Balance problems can lead to a myriad of functional problems and safety issues, which can require ongoing assistance if left untreated. Balance requires coordination of a variety of systems in order to work optimally. Should any of these systems become affected, balance problems or other symptoms can lead to functional issues.

When you have poor balance, you have a high risk of falling and experiencing another brain injury or broken bone. Maintaining balance while sitting and standing is important for all of our daily activities, including self-care and walking. Poor balance can keep you from taking part in many types of activities, such as sports, driving, and work.

Treatment depends upon the cause of the problem. At Centre Naprej we perform a lot of different rehabilitation programs; most of them are sport-related and dealing with balance problems of our users.

2 CENTER NAPREJ MARIBOR

The Center Naprej is a specialized regional center providing high intensity, individual and group programs of long-term rehabilitation for people with ABI. All services and programs focus on an active reintegration of patients into social and professional life, achieving independence from family members and other forms of assistance, raising the quality of their lives as of their relatives. An integrated multidisciplinary professional approach is based on respect, cooperation and individuality of patients. It is a multi-layer, sensitive and complex process. All parts of the process have a scientific basis and are carefully planned. It requires an individualized, harmonized and continuous professional assistance allowing the user to regain control over their lives and maximum participation within the community. The rehabilitation program is carried out every working day between 07:00-15:00, from 5 to 8 hours daily. The service is free of charge for beneficiaries.

Within the program, we perform psychosocial and healthcare services: healthcare, management and employment under special circumstances, rehabilitation and psychosocial rehabilitation, psychological, psychotherapeutic and psychiatric treatment, neuro-physiotherapy, occupational therapy, educational programs as well as preventive programs.

In addition to regular programs we also carry out numerous additional, above standard programs such as sport rehabilitation, trips, holidays, winter holidays, visiting cultural events, sport and social activities, etc.

Within intensive individual and group neuro-physiotherapeutic and occupational therapy, we perform different programs and place special emphasis on sport rehabilitation activities.

Sport is part of human activities, which is important for all of us and has the enormous potential to connect people and reaches every individual, regardless of age, social origin, individuality, race, and gender. The basic objective of sport activities are the optimization of psychosomatic status of a person, effective use of their spare time, execution of preventive healthcare measures, improvement of health and general well-being as well as recovery.

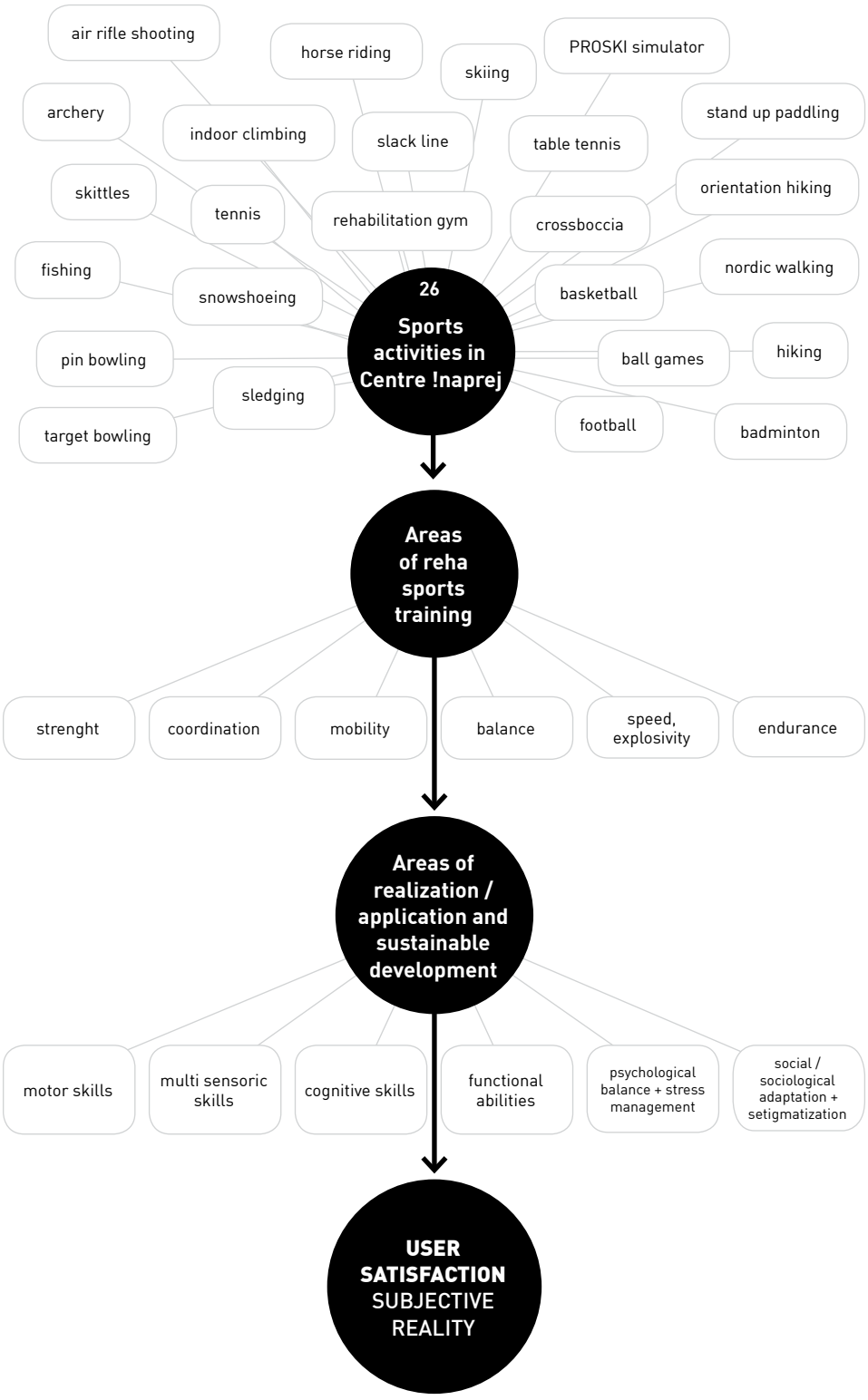
Sport rehabilitation provides strengthening and relative normalization of afferent nerve impulses of the main vessels from muscles and joints. By synthesizing exercises, the central brain structures, which are responsible for movement activities, are activated. This provides the users the ability ease pathologic reflexes and stimulates the development of new physiological movement patterns.

From the perspective of the body, we can strengthen and improve cardiovascular fitness, physical power and endurance, respiratory capacities, musculoskeletal and immune system, maintain mobility, stability and coordination, develop neuromuscular mechanism within the healthy parts of the body for purposes of compensation of lost functions, etc. Individual goals of users within these sport and rehabilitation activities can also include weigh management and body shaping.

From the psychological perspective, sports can contribute to mental relaxation or fun and activation. Sports have a positive impact on self-image and a sense of own value. It can also represent a space for personal creativity, a means to fulfill own wishes and achieving internal balance, satisfaction and connection with the nature as well as a form of establishment.

The sports rehabilitation programs are complemented with cognitive and social training, psychological and psychotherapeutic treatment, speech therapy and other complementary therapies.

Within sports rehabilitation we perform numerous sport activities. We are especially interested in the impact of sports activities on users, therefore we wish to monitor, measure and analyze the effects of sports activities in rehabilitation.


air rifle shooting
horse riding
skiing
PROSKI simulator
archery
indoor climbing
slack line
table tennis
stand up paddling
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pin bowling
ball games
hiking
sledging
target bowling
football
badminton
Areas of reha sports training
strenght
coordination
mobility
balance
speed, explosivity
endurance
Areas of realization / application and sustainable development
motor skills
multi sensoric skills
cognitive skills
functional abilities
psychological balance + stress management
social / sociological adaptation + setigmatization
USER SATISFACTION
SUBJECTIVE REALITY

2.1. Winter sport rehabilitation program: alpine skiing and proper preparation

One of the important programs we introduced into our rehabilitation programs for training and testing the balance of users is alpine skiing. It is an integrated and demanding activity with significantly increased risk level for our users. The analysis has shown that poor balance represents the highest risk in the skiing rehabilitation program as it increases the risk of falling and consequently the risk of repeated brain injury or fracture. Such activity, with emphasis on balance training, is of significant importance for all everyday activities, including care and walking.

2.2. Training on pro ski simulator

Once we were given the possibility to upgrade the ski training with exercises on PRO SKI SIMULATOR, we noticed significant progress over a short period of time. The first few workouts have already have shown that we are achieving much better rehabilitation results with this additional program – improved balance, physical strength and fitness.

Workout on PRO SKI SIMULATOR has numerous positive effects on the human organism and high preventive effect on our health. We quickly realized that the mentioned workout is suitable for disabled skiers as well as other users with ABI who do no ski. On account of visible positive effects we decided to test the effects of such workout on people with ABI. We designed a research frame: test-retest method and performed 10 workouts on PRO SKI SIMULATOR.

3. PRO SKI TRAINING, SIMULATOR ANALYSIS AND WORKOUT SPECIFICATIONS

3.1 Pro ski training system

PRO SKI TRAINING is a specific set of interrelated methodological, fitness and rehabilitation training operators on PRO SKI SIMULATOR. PRO SKI training positively affects energy (calories) consumption, learning and development of ski movements, development of a large number of motor and functional skills, stability and mobility of extremities .

Among motor skills, the largest effect is achieved in the development of balance (static and dynamic) and coordination, leg strength (repetitive, explosive and plyometric), static and repetition strength of trunk, arms and shoulders, agility and proprioception. While in the development of functional abilities positively affects on the aerobic and anaerobic capacity .

PRO SKI training somehow simulates skiing under controlled conditions with over 1500 basic exercises with and without equipment to be used during workout.

The system of training on the sophisticated PRO SKI SIMULATOR training machine is adapted to the entire population, from complete non-skiers, children and the elderly to top skiers and athletes. During the training, which lasts about 60 minutes under controlled and adjusted conditions, you can burn more than 1.000 calories.

Training in a group or individually has an impact on a large number of motor skills, with emphasis on balance (dynamic and static), coordination, rhythm, agility, explosive power, speed, while using a variety of additional equipment (dumbbells, weights, difficult ski poles, sticks, rubber, medicine ball, etc.), develops shoulder and shoulder belt , strengthens the lumbar region of the body and provides high energy consumption and thus the loss of fat tissue in critical regions of the body. It is also one of the few programs, which unlike skiing, can train and rehabilitate people with injured joint systems (knee, foot, hip and back).

It is also convenient for working with people with intellectual disabilities because of the enormous affect on the development of cognitive skills because of the involvement of both hemispheres of the brain.

This type of training is highly effective as it allows a large number of reps during a workout. For example, if the objective of the training is the development of the upper body, legs will always run between 4000 and 6000 contractions. The exercises for the upper body can be repeated between 1500-2500 times and thus influence the development of the whole body.

All exercises are performed dynamically, with or without equipment. Attention is paid to the proper execution of exercises when working on PRO SKI SIMULATOR.

3.2 Pro ski simulator – expert evaluation of intended function and applicability

The construction and functionality of PRO SKI SIMULATOR - it provides numerous possibilities and manners of movement.

The use of PRO SKI SIMULATOR can be a good foundation for acquiring basic movement information and learning certain basic movements. This is a positive movement transfer whereby it is important to stress the fact that the proper use of the device is only one of the segments of quality-based preparations for the skiing season.

In addition to dimension of informational movement components (balance, coordination, etc.), the exercises (load) require highly developed dimensions, which are a part of the so-called energetic component of movement (strength, speed, endurance).

Adjustable elastic bands make the PRO SKI SIMULATOR suitable for different morphological types of users. By using the device, we improve the primary as well as special motor skills, e.g. balance, endurance and coordination.

Beside the mentioned advantages, PRO SKI SIMULATOR provides the option of movable or non-movable pedals, which is undoubtedly an important characteristic.

PRO SKI SIMULATOR is appropriate for the adults as well as for children. It is also suitable for use in rehabilitation (knee, hip injuries, etc.).

3.3 Biomechanic analysis on pro ski simulator

Proper technical performance is affects by the high complexity of biomechanical parameters, respectively control of kinematic and dynamic parameters. The fundamentals of kinematic parameters make spatial (path, trajectory and angular relationships), time (duration) and spatial-time parameters (speed and acceleration). Dynamic parameters are associated with muscle power, resistance force and reactive power. While working on the simulator, the mentioned forces are under the direct influence of the elastic force of rubber resistance, pressure force on the surface, gravity, inertia, friction force and the force of rubber reaction.

The user is mastering the technique with synchronized muscle contractions of agonists and antagonists and trying to master the forces that act on the body during exercise on a simulator.

When starting the movement of the simulator, the force of leg muscle is very

important. Specifically, concentric contraction of the agonist leg achieves greater muscular force than the force of rubber resistance. Required concentric contraction of the agonist also depends on the number of rubbers or resistance of rubbers, which is smaller around the middle of the simulator than on the ends. Specifically, the elastic properties of rubber around the middle of the simulator ha less power than on the end when the force increases due to reaching maximum elasticity, which depends on the set number of rubbers. Larger number of rubbers - higher resistance. At the time of reaching maximum elastic force, if the rubber resistance is greater than the force we provide on the simulator, rubbers will be shortened and returned to the original/start position. In that moment the rubber reaction force is the greatest and requires high synchronization of leg agonist and antagonist as well as the kinematic parameters like the angle between the upper part (trunk) and lower part (legs). If all of these parameters are fulfilled, the user can safely and without disrupting the balance perform the exercise/s.

In addition to the dynamic properties of the simulator, inertial force is of great importance. It depends on the working speed and acting contrary to the elasticity force of rubbers. With higher working speed, the body will move faster out of inertia and distort the balance of trainees.

3.4 Muscle anatomy on pro ski simulator

As in any sporting activities, PRO SKI or exercise on the PRO SKI SIMULATOR applies specific dominance of certain topological regions, muscle groups and muscles. On PRO SKI SIMULATOR identical muscle groups as during skiing dominate - trunk (CORE), hips and legs for their flexion, extension and rotation.

Among muscle groups and muscles, which primarily dominate during PRO SKI workout are upper leg muscles (quadriceps femorism, m. gluteus maximus and medius, M.sartorius , m. Iliopsoas,), lower leg muscles (tibialis anterior, extensor digitorum longus, musculus soleus and peroneus longus), foot (extensors), CORE-trunk and back (latissimus dorsi, thoracolumbar fascia and m.obliquus eksternus abd.).

The use of additional exercises with equipment additionally activate upper leg muscles (adductor longus), lower leg muscles (gastrocnemius), arms and shoulders (triceps, flexors and the extensors, biceps, deltoid muscles, trapesius), trunk, chest and back (trapesius, Teres minor and major, pectoralis and rectus abdominus). All these muscle groups and muscles must be well coordinated with each other, because they have separate functions during exercise. Also, do not forget the importance of proprioceptors and their coordination with the vestibular apparatus for maintaining the balanced position.

4 OBJECTIVE AND HYPOTHESIS

4.2 Work objective

The primary objective is to find differences between provided tests targeted on balance, before and after 10 PRO SKI workouts.

The secondary objective is to find differences between provided tests targeted on coordination and rhythm, before and after 10 PRO SKI workouts.

4.3 Hypothesis

H1 - The implementation of the primary program for the development of balance and secondary program for the development of coordination and rhythm, there was a change in the measured tests.

H0 - The implementation of the primary program for the development of balance and secondary program for the development of coordination and rhythm, there was no change in the measured tests.

5 WORK METHODS

5.1 Sample of subjects

We included in the study 11 users. All users were enrolled into regular everyday rehabilitation program.

We first assessed the mobility of users by using the FIM (Functional Independence Measure) and FAM (Functional Assessment Measure) with two scales to assess the physical and cognitive skills of patients (users) and their level of independence.

The FIM scale is most commonly used tool for assessing an outcome in rehabilitation medicine. The FAM scale is designed as a supplement to the FIKM scale with the intention to provide more information on patients after brain trauma or cerebral insult. The scale consists of 12 items which are evaluated on a 7-point scale. For study purposes we used the movement assessment, specifically walking, which is the foundation for enrollment into our program on a 7-point scale.

The average movement score on the FIM scale for enrolled users was 5.09, the lowest score 3 and the highest score 6.

ENROLLED USERS:

We included in the study 11 users (6 of which had additional ski training as before). All users were included into regular everyday rehabilitation programs.

USERS	M	F	ALL
	9	2	11
ADDITIONAL SKI TRAINING	6	0	6
FIM – WALK EVALUATION – MEAN VALUE	5.22	3.5	5.09
RANGE OF FIM SCORE	MAX. 6, MIN. 3		

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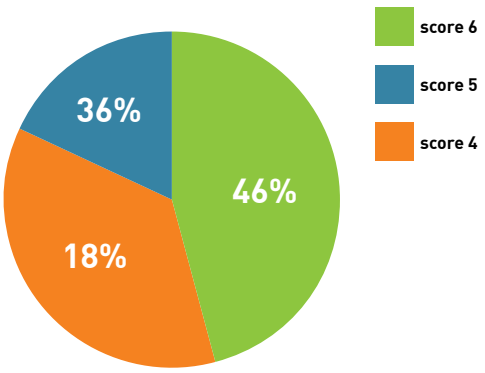
	CRITERIA
1	COMPLETE ASSISTANCE Independently performs less than 25% of activities and the rest with a physical assistance by another person.
2	MAXIMUM ASSISTANCE Independently performs 25% - 49% of activities and the rest with a physical assistance by another person.
3	MODERATE ASSISTANCE Independently performs 50% -74% of activities and the rest with a physical assistance by another person.
4	MINIMUM ASSISTANCE Independently performs at least 75% of activities and the rest with a physical assistance by another person.
5	MONITORING Requires another person for guidance, direction, encouragement and proper adjustment of the environment.
6	MODIFIED INDEPENDENCE Requires accessories and more time for performing an activity and does not require assistance from another.
7	COMPLETE INDEPENDENCE Perform an activity safely and in appropriate time.
8	Non-evaluated user

The average movement score on the FIM scale for enrolled users was 5.09, the lowest score 3 and the highest score 6.



5.2 Tests sample and measuring instruments

Static and dynamic balance tests

Test 1. MB1 → static balance 1; standing up to max 30 sec. on one leg with other leg backward.

Test 2. MB2 → static balance 2; standing up to max 30 sec. on one leg with other leg forward.

Test 3. MB3 → static balance 3; standing up to max 30 sec. on one leg with other leg of the body.

Test 4. MB4 → dynamic balance 1; standing up to max 30 sec. on one leg with moving other leg forward and backward.

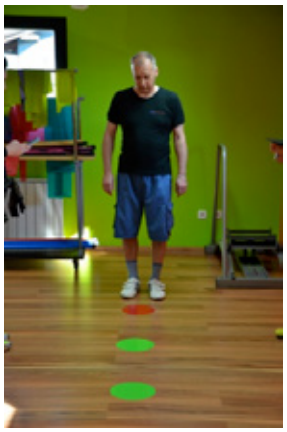
Tests 1, 2, 3, and 4 where measured on the wooden hard floor with stopwatch.



Test 5. MRK1 → coordination and rhythm 1; walking/ running forward on colored spots on the floor.

Test 6. MRK2 → coordination and rhythm 2; walking/ running forward on colored spots on the floor, with the predetermined task and vocabulary asistance.

Tests 5 and 6 where measured on the wooden hard floor with stopwatch. On the floor where colored spots on which are used for walking/running on them with various tasks.

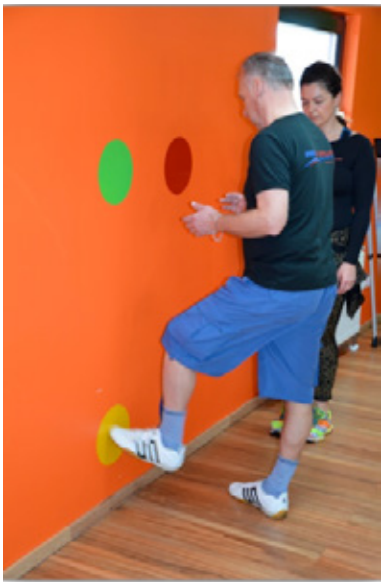
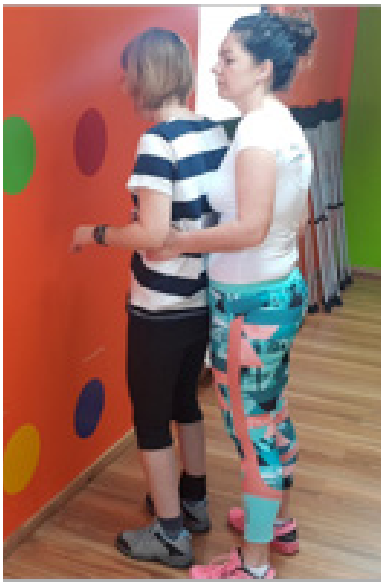
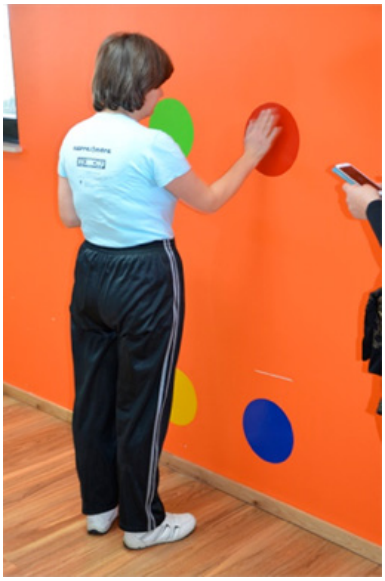


Test 7. MRK3 → coordination and rhythm 3; clap/leg; coordination of arms and legs with the specified task on the points/spots on the wall.

Test 8. MRK4 → coordination and rhythm 4; hand/leg; coordination of arms and legs with

the non specified task on the points/spots on the wall.

Tests 7 and 8 where measured on the wooden hard floor and 4 spots on the wall with stopwatch. On the wall where colored spots in 4 different colors (yellow, green, blue and red) which are used for specified and non specified tasks.

5.3 Data collection methods

5.3.1. Diagnostic procedure before and after the implementation of the program

Diagnostic procedure was performed at PRO SKI SIMULATOR training center in Maribor, Slovenia. The initial test was carried out on 18 November2015 and final test on 3 February 2016. Both tests where measured at the same time in a day.

The schedule of the measurement was the same during both (initial and final) tests. Also, the resting time between tests was the same. So, possible exogenous influences were minimized.

The implementation of the measurement procedure consists of two sets of tests. The first group refers to the static and dynamic balance (activation of proprioceptors). It consists of three tests, which are focused on static balance, and one test of dynamic balance.

The second group of tests focused on coordination and rhythm. It consists of 4 different tests. Two tests measured only the coordination of legs while walking or running on the floor. And the other two test was measuring coordination and rhythm of legs and arms/hands together.

PROTOCOL OF PROVIDED TESTS

1 group: static and dynamic balance

1. Test - standing up to max. 30 sec. on right leg with left leg backward.
   - Pause 20 sec.
2. Test - standing up to max. 30 sec. on left leg with right leg backward.
   - Pause 5 min.
3. Test – standing up to max. 30 sec. on right leg with left leg forward.
   - Pause 20 sec.
4. Test – standing up to max. 30 sec. on left leg with right leg forward.
   - Pause 5 min.
5. Test - standing up to max 30 sec. on right leg with the left leg of the body.
   - Pause 20 sec.
6. Test - standing up to max 30 sec. on left leg with right leg of the body.
   - Pause 5 min.
7. Test - standing up to max 30 sec. on right leg with moving left leg forward and backward.
   - Pause 20 sec.
8. Test - standing up to max 30 sec. on left leg with moving right leg forward and backward.

DETAILED DESCRIPTION OF FIRST TESTS GROUP

The first tree tests in this group of tests are measuring static balance in tree different positions. The fourth test is measuring dynamic balance.

In all 4 tests the starting positions are the same. Standing on one leg with arms wide open. Tests are measured with the stopwatch maximum time of 30 sec.

In the first test the leg which is not on the floor is placed backwards and flexed in knee joint.

In the second test the leg which is not on the floor is placed forward and also flexed in knee joint.

In the third test the leg which is not on the floor is extended off the body.

And in the last test, dynamic balance test is measuring the movements of the leg which is not on the floor. Repetitions are counting forward and backward and also the time of standing on the leg which is on the floor is measured. All tests stop when other leg steps on the floor.

2 group: coordination and rhythm

1. Test – walking/running on 8 colored spots/points with specifized task. The task is to step on each point, successively with left and right leg.
   - Pause 20 sec.
2. Test - walking/running on 8 colored spots/points with specifized task and assistance. The task is to step on each point, with wright leg. For example: blue and red spot with left leg; yellow and green with right leg. Reminding vocabulary assistance is possible.
   - Pause 5 min.

3. Test – Specifized test for rythm and coordination. Clap with hands and then touch with left or right leg on left or right low spot/point on the wall. Test is measured up to 30 sec. And counting each clap after touching a successively low point with left or right leg/foot.

- Pause 20 sec.

4. Test – Non specifized test for rythm and coordination. Touch with left or right leg left or right low spot/point on the wall. And touch with left or right hand left or right high spot/point on the wall. Measurer is giving a task like »left hand«, »right leg«... and on that sign exerciser must exactly touch the right point. Test is measured up to 30 sec. And counting each wright touch on the wall.

5.3.2. PROGRAM AND IMPLEMENTATION OF PRIMARY TRAINING OPERATORS FOR BALANCE DEVELOPMENT AND SECONDARY FOR DEVELOPMENT OF COORDINATION AND RHYTHM

The training program of 10 sessions is containing integrated motions to impact on the primary and secondary tasks during the entire period.

Targeted differences during each workout were in the stages of training. Introductory, preliminary, main and final part of the training. These differences can manifest itself in extensity and intensity of workout, complexity of performance and speed of performing the exercises according to a predetermined rhythm of the music in the background. However, in each training there were over 4500 lateral movements with deferent tasks/exercises.

INTRODUCTORY PART

Period: 5-7 min.
Tempo/Rhythm/Repetitions: 90-100 per min.

During each workout in the introductory part, the emphasis was on correct and secure posture of the body during lateral movement. With simple tasks, maximal concentration was at the correct movements in joints of the foot, knee and hip. That in the later parts of the training, tasks could be more complexed, with increased influence on a complete loco motor system and cognitive abilities.

PRELIMINARY PART

Period: 7-9 min.
Tempo/Rhythm/Repetitions: 100-110 per min.

In preliminary part we focused on preparing for a major part of the training. Speed of performance was higher as well as extensity and intensity of exercise. The exercises have been more complexed, with an emphasis on coordination of upper body movements.

MAIN PART

Period: 30-35 min.
Tempo/Rhythm/Repetitions: 100-120 per min.

After 15 minutes of introductory and preliminary part each training included 30-35 minutes of main training. In that part we integrated all motor skills on which we focused. Dynamic and static balance with coordination of upper and lower part of body. Using different requisites, like ropes, poles, weight poles, dumbbells, elastics, gym balls, small anti-stress balls, the influence on coordination and balance was much higher than without it! However, every exercise/movement has to be done correctly and according to the rules of PRO SKI TRAINING SYSTEM. Except already mentioned motor skills, during correct motions with specified tasks, exercises had a large influence on developing cognitive abilities as well as the right and left hemisphere of a brain. Every main part of the training had a small active pause, about 5 minutes, which contained correctional exercise or instructions for fixing mistakes that occurred during the training.

FINAL PART

Period: 5 min.
Tempo/Rhythm/Repetitions: 0 per min.

At the end of each training session, we focused on the relaxation of muscles and muscle groups by reducing the intensity of work and using exercises to develop mostly static flexibiliy.

5.4. Methods of data processing

5.4.1. Descriptive statistic

The term descriptive statistics involves description of variables. Each variable separately, we underwent with descriptive methods of data processing and then we analyzed the relationship between the results.

As the basic statistical parameters for analysis of the results, we have included:

- Maximum and minimum result in the test
- Arithmetic mean
- Standard deviation and variance

The arithmetic mean is one of possible ways of calculating the average or the measure of central tendency. This is the ratio between the sum of all results in a row and the number of results.

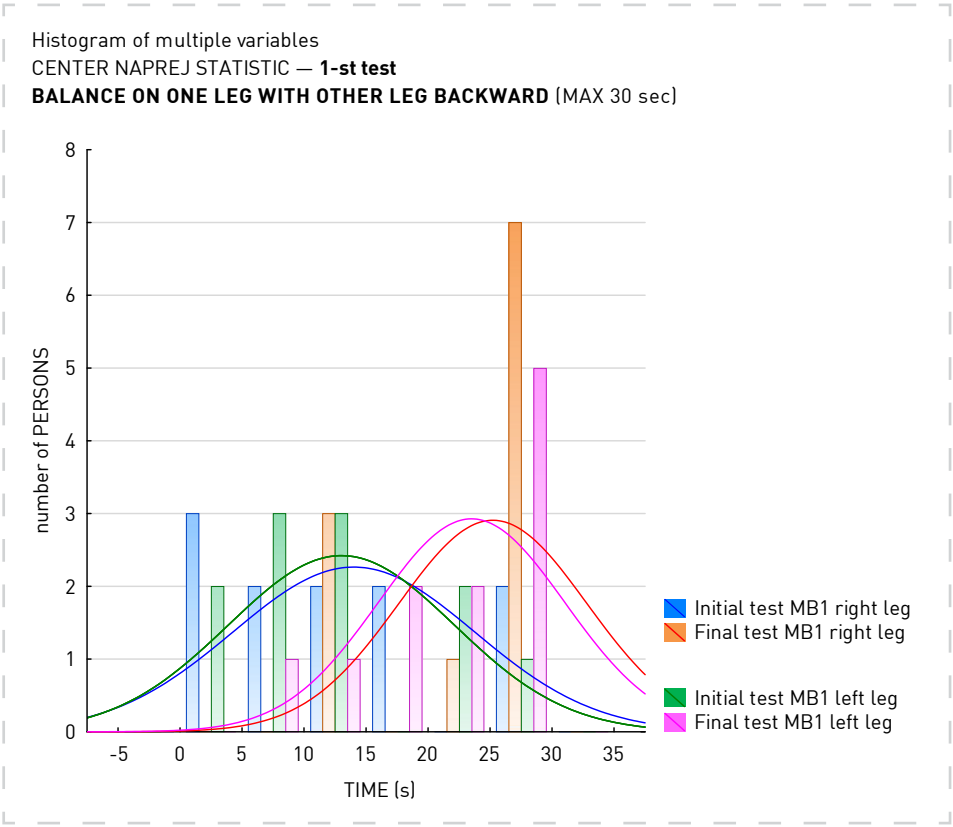
The standard deviation and variance are measures of dispersion or variability of results from the arithmetic mean. They are showing the average deviation of all results from the arithmetic mean.

6.
RESULTS

1st GROUP – Static and dynamic balance

1. Test MB1: initial and final measurement for left and right leg.

Standing on one leg with the other leg backward. Max. Performance of test is 30 sec.



Graph 1.
Initial and final test. 1. test for evaluation of static balance

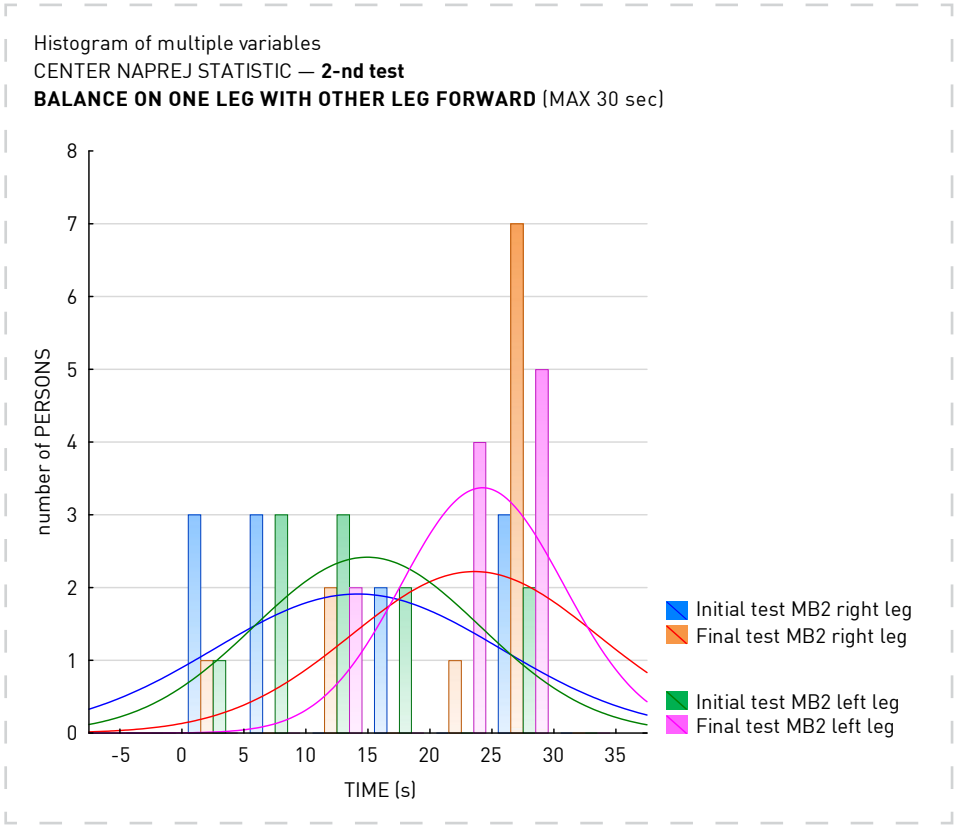
	INICIAL TEST MB1 LEFT LEG	FINAL TEST MB1 LEFT LEG	percentage	INICIAL TEST MB1 RIGHT LEG	FINAL TEST MB1 RIGHT LEG	percentage
MEAN case 1-11	**13,90909091**	**25,06363636**	**80,2%**	**12,90909091**	**23,35454545**	**80,9%**
MEDIAN case 1-11	12,6	30		10,6	23,7	
SD case 1-11	**9,691280054**	**7,545895935**	**-22,1%**	**9,060734468**	**7,495647222**	**-17,3%**
VALID_N case 1-11	11	11		11	11	
SUM case 1-11	**153**	**275,7**	**80,2%**	**142**	**256,9**	**80,9%**
MIN case 1-11	2,6	12		1,4	9,1	
MAX case 1-11	30	30		30	30	

Table 1.
Results MB1. The test for the assessment of static balance. Final and initial measurement.

1st GROUP – Static and dynamic balance

2. Test MB1: initial and final measurement for left and right leg.

Standing on one leg with the other leg forward. Max. Performance of test is 30 sec.



Graph 2.
Initial and final test. 2. test for evaluation of static balance.

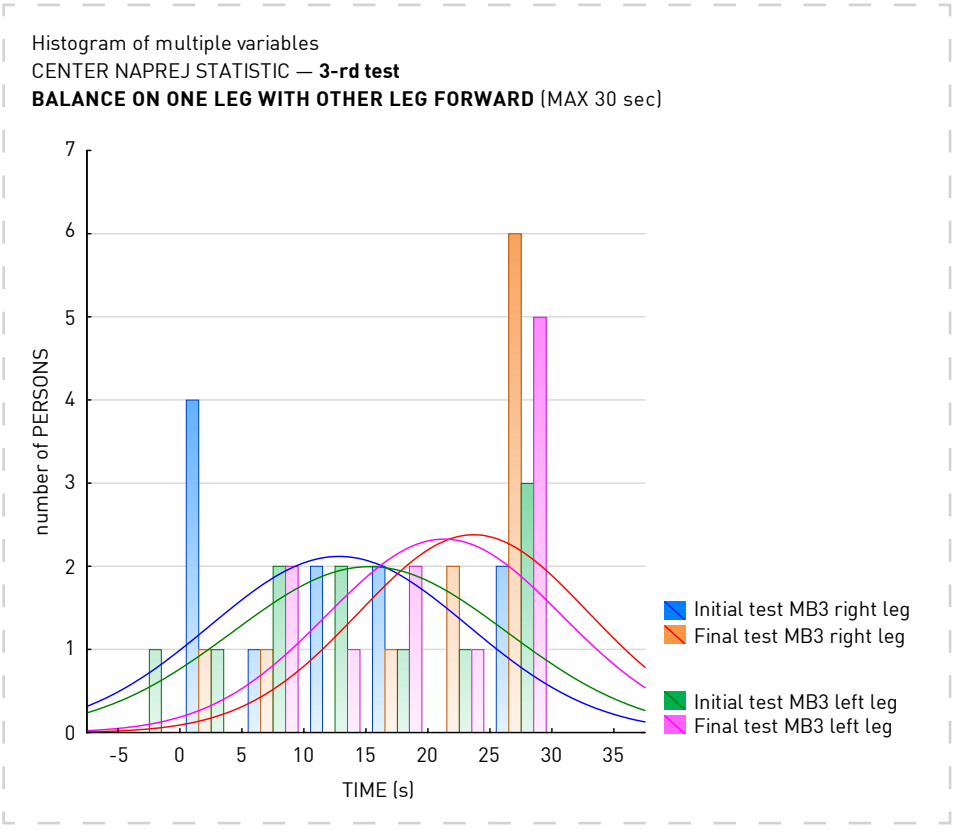
	INITIAL TEST MB2 RIGHT LEG	FINAL TEST MB2 RIGHT LEG	percentage	INITIAL TEST MB2 LEFT LEG	FINAL TEST MB2 LEFT LEG	percentage
MEAN case 1-11	14,06363636	23,42727273	66,6%	14,82727273	24,07272727	62,4%
MEDIAN case 1-11	7,8	30		13,8	24	
SD case 1-11	11,48087738	9,885048397	-13,9%	9,078225698	6,507394395	-28,3%
VALID_N case 1-11	11	11		11	11	
SUM case 1-11	154,7	257,7	66,6%	163,1	264,8	62,4%
MIN case 1-11	2,6	4		2,7	12,2	
MAX case 1-11	30	30		30	30	

Table 2.
Results MB2. The test for the assessment of static balance. Final and initial measurement.

1st GROUP – Static and dynamic balance

3. Test MB3: initial and final measurement for left and right leg.

Standing on one leg with the other leg of the body. Max. Performance of test is 30 sec.



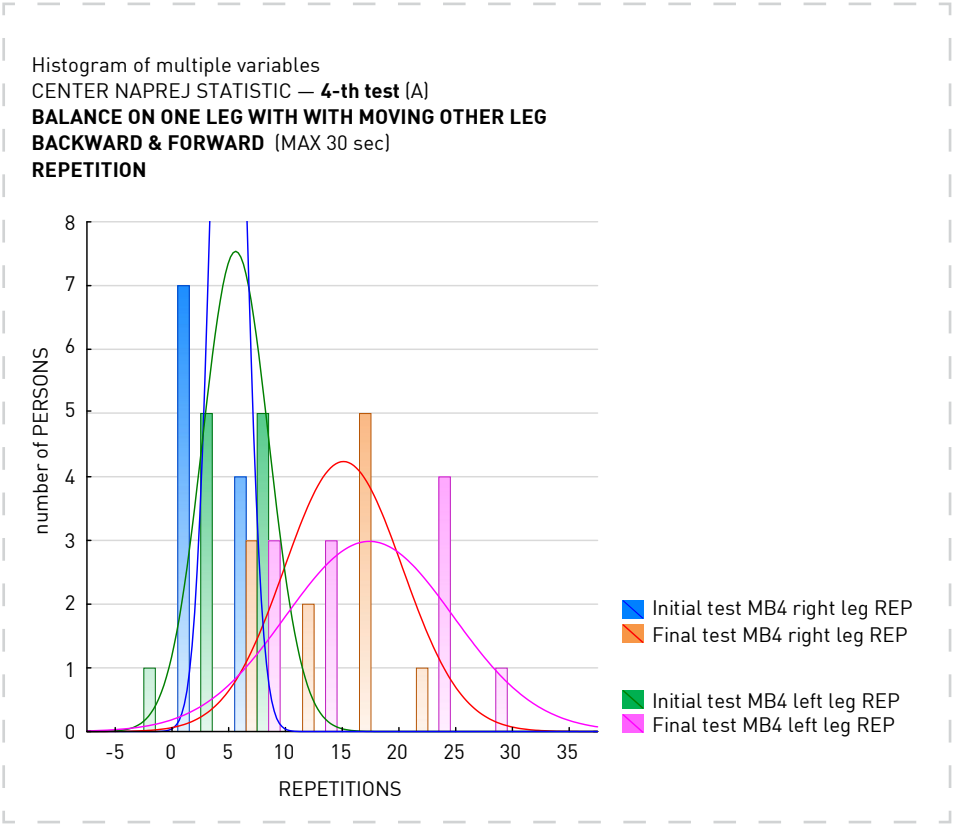
Graph 3.
Initial and final test. 3. test for evaluation of static balance.

	INITIAL TEST MB3 RIGHT LEG	FINAL TEST MB3 RIGHT LEG	percentage	INITIAL TEST MB3 LEFT LEG	FINAL TEST MB3R LEFT LEG	percentage
MEAN case 1-11	12,72727273	23,53636364	84,9%	15,19272727	21,16363636	39,3%
MEDIAN case 1-11	13,4	30		12,6	22,5	
SD case 1-11	10,35751813	9,223586366	-10,9%	10,99618942	9,43051141	-14,2%
VALID_N case 1-11	11	11		11	11	
SUM case 1-11	140	258,9	84,9%	167,12	232,8	39,3%
MIN case 1-11	1	4,9		0	6	
MAX case 1-11	30	30		30	30	

Table 3.
Results MB3. The test for the assessment of static balance. Final and initial measurement.

1st GROUP – Static and dynamic balance

4(A). Test MB4 REPETITION: initial and final measurement for left and right leg.
Standing on one leg with moving successively other leg forward and backward.
Max. Performance of test is 30 sec.



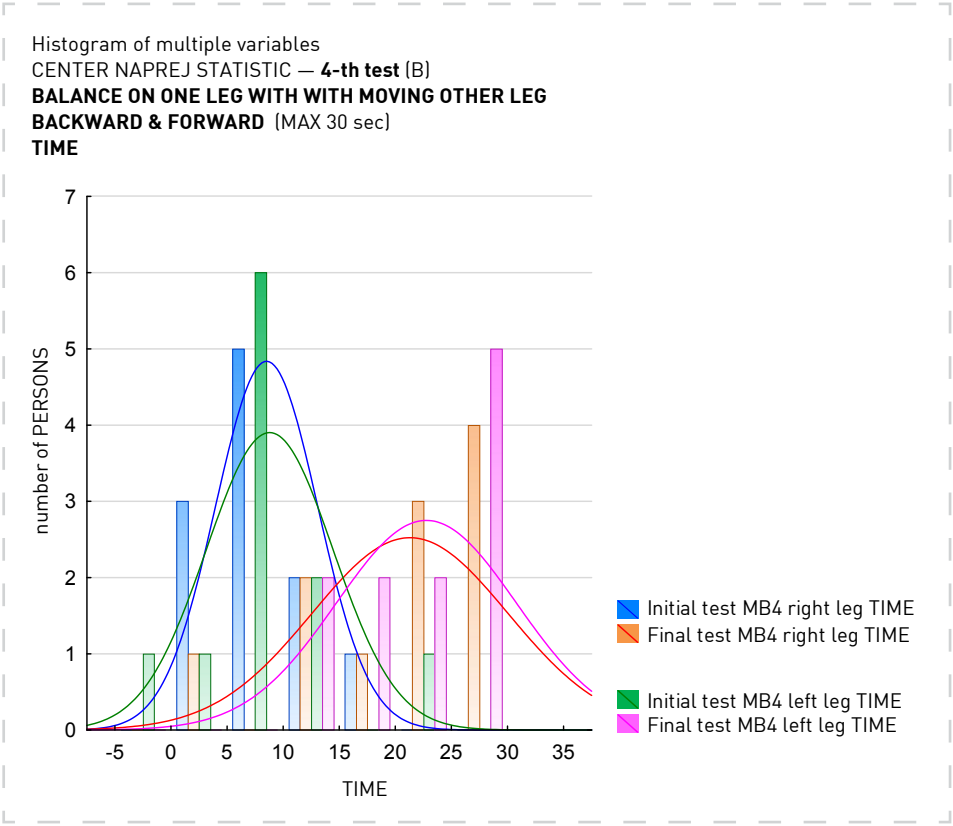
Graph 4.
Initial and final test. 4. test for evaluation of dynamic balance.

	INITIAL TEST MB4 RIGHT LEG REP	FINAL TEST MB4 RIGHT LEG REP	percentage	INITIAL TEST MB4 LEFT LEG REP	FINAL TEST MB4 LEFT LEG REP	percentage
MEAN case 1-11	**4,909090909**	**15**	**205,6%**	**5,545454545**	**17,27272727**	**211,5%**
MEDIAN case 1-11	5	16		5	15	
SD case 1-11	1,445997611	5,176871642	**258,0%**	2,910794955	7,34970624	**152,5%**
VALID_N case 1-11	11	11		11	11	
SUM case 1-11	**54**	**165**	**205,6%**	**61**	**190**	**211,5%**
MIN case 1-11	3	7		0	7	
MAX case 1-11	7	23		10	30	

Table 4.
Results MB4. The test for the assessment of dynamic balance. Final and initial measurement.

1st GROUP – Static and dynamic balance

4(B). Test MB4 TIME: initial and final measurement for left and right leg.
Standing on one leg with moving successively other leg forward and backward.
Max. Performance of test is 30 sec.



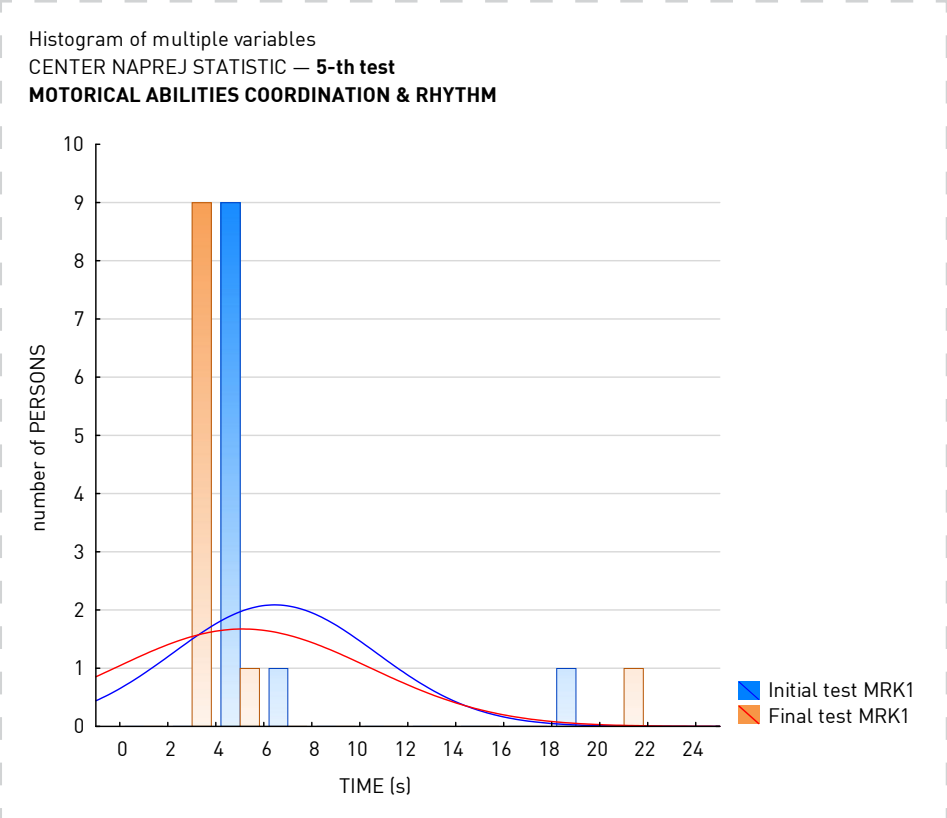
Graph 5.
Initial and final test. 4. test for evaluation of dynamic balance.

	INITIAL TEST MB5 RIGHT LEG TIME	FINAL TEST MB5 RIGHT LEG TIME	percentage	INITIAL TEST MB5 LEFT LEG TIME	FINAL TEST MB5 LEFT LEG TIME	percentage
MEAN case 1-11	8,445454545	21,16363636	150,6%	8,718181818	22,61818182	159,4%
MEDIAN case 1-11	7,1	22,9		7,9	24	
SD case 1-11	4,535937309	8,696467412	91,7%	5,623134034	7,979074907	41,9%
VALID_N case 1-11	11	11		11	11	
SUM case 1-11	92,9	232,8	150,6%	95,9	248,8	159,4%
MIN case 1-11	2,6	4		0	10,8	
MAX case 1-11	18	30		23	30	

Table 5.
Results MB4. The test for the assessment of dynamic balance. Final and initial measurement.

2-nd GROUP – Coordination and rhythm

5. Test MRK1: Initial and final test.
Walking/running forward on colored spots on the floor.



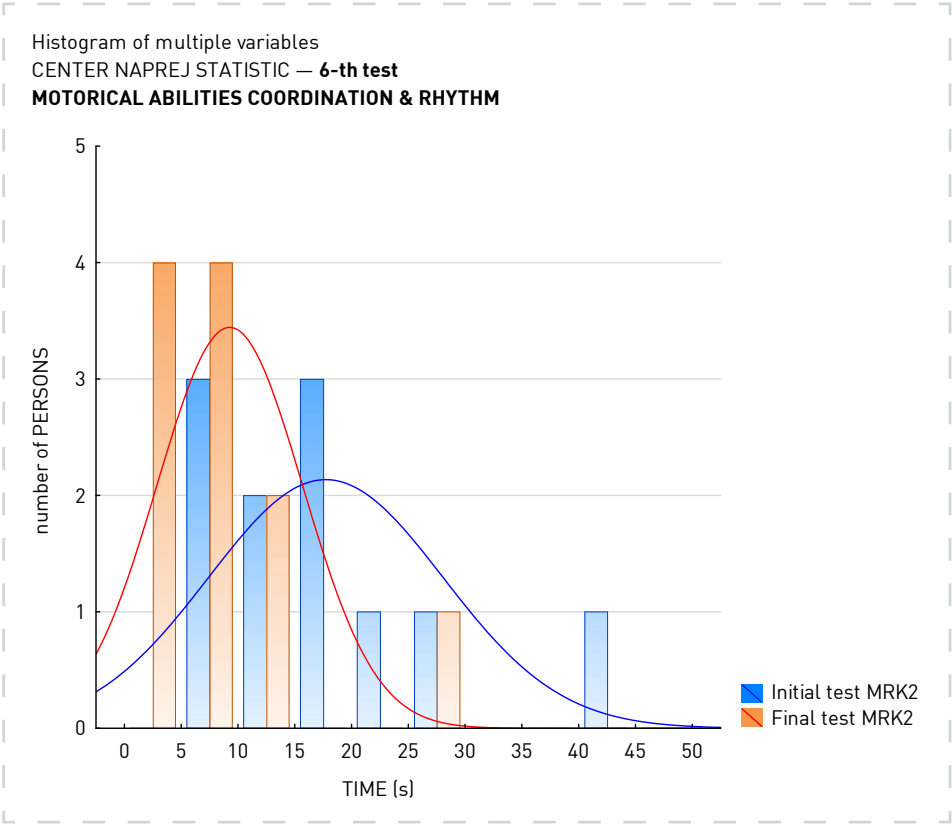
Graph 6.
Initial and final test. 1. test for evaluation of coordination and rhythm.

	INITIAL TEST MRK1	FINAL TEST MRK1	percentage
MEAN case 1-11	**6,418181818**	**5,090909091**	**-20,7%**
MEDIAN case 1-11	5,3	3,3	
SD case 1-11	4,203288756	5,244321604	**24,8%**
VALID_N case 1-11	11	11	
SUM case 1-11	**70,6**	**56**	**-20,7%**
MIN case 1-11	4,1	2,7	
MAX case 1-11	18,9	20,8	

Table 6.
Results MRK1. Test for the assessment of coordination and rhythm. Final and initial measurement.

2-nd GROUP – Coordination and rhythm

6. Test MRK2: Initial and final test.
Walking/running forward on colored spots on the floor, with the predetermined tasks and assistance.



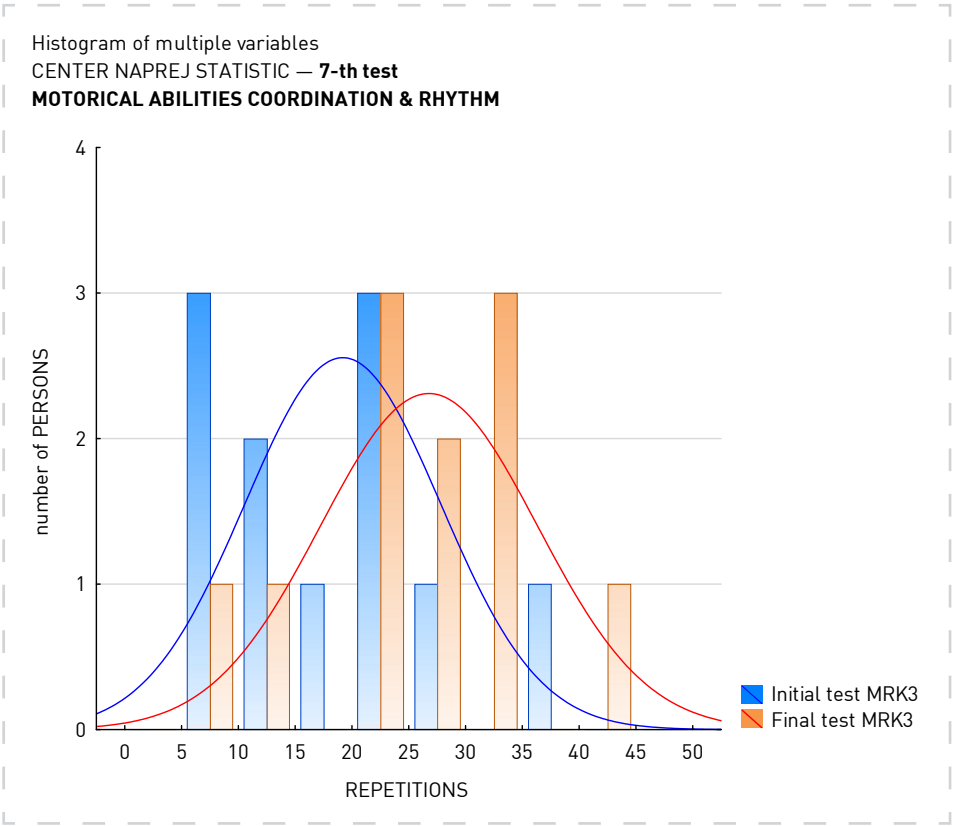
Graph 7.
Initial and final test. 2. test for evaluation of coordination and rhythm.

	INITIAL TEST MRK2	FINAL TEST MRK2	percentage
MEAN case 1-11	**17,63636364**	**9,218181818**	**-47,7%**
MEDIAN case 1-11	18,2	8,3	
SD case 1-11	10,2734875	6,371313551	**-38,0%**
VALID_N case 1-11	11	11	
SUM case 1-11	**194**	**101,4**	**-47,7%**
MIN case 1-11	7,4	3,9	
MAX case 1-11	41,8	26,7	

Table 7.
Results MRK2. Test for the assessment of coordination and rhythm. Final and initial measurement.

2-nd GROUP – Coordination and rhythm

7. Test MRK3: 7. Test MRK3: Initial and final test.
Clap/leg; coordination of arms and legs, specified task with the points/spots on the wall.



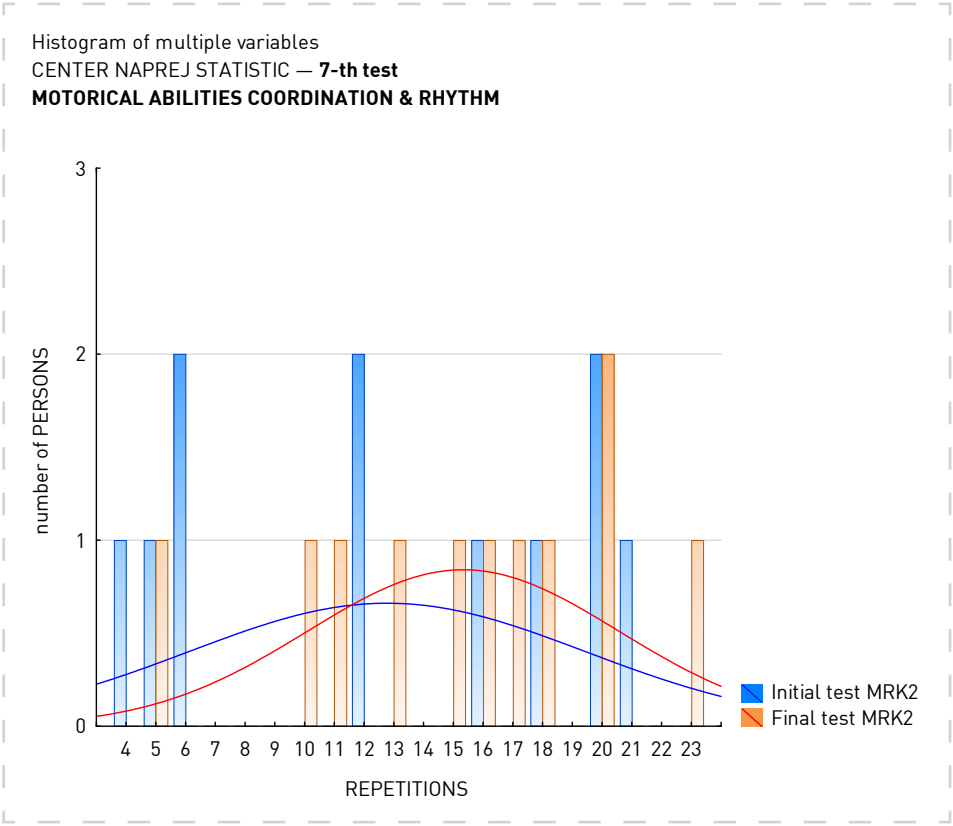
Graph 8.
Initial and final test. 3. test for evaluation of coordination and rhythm.

	INITIAL TEST MRK3	FINAL TEST MRK3	percentage
MEAN case 1-11	**19,09090909**	**26,63636364**	**39,5%**
MEDIAN case 1-11	19	29	
SD case 1-11	8,584340924	9,500239231	**10,7%**
VALID_N case 1-11	11	11	
SUM case 1-11	**210**	**293**	**39,5%**
MIN case 1-11	9	8	
MAX case 1-11	36	43	

Table 8.
Results MRK3. Test for the assessment of coordination and rhythm. Final and initial measurement.

2-nd GROUP – Coordination and rhythm

8. Test MRK4: 7. Test MRK3: Initial and final test.
Hand/leg; coordination of arms and legs, non specified task with the points/spots on the wall.



Graph 9.
Initial and final test. 4. test for evaluation of coordination and rhythm.

	INITIAL TEST MRK4	FINAL TEST MRK4	percentage
MEAN case 1-11	**12,72727273**	**15,27272727**	**20,0%**
MEDIAN case 1-11	12	16	
SD case 1-11	6,634619945	5,217104735	**-21,4%**
VALID_N case 1-11	11	11	
SUM case 1-11	**140**	**168**	**20,0%**
MIN case 1-11	4	5	
MAX case 1-11	21	23	

Table 9.
Results MRK4. Test for the assessment of coordination and rhythm. Final and initial measurement.

7 DISCUSION

The results of the initial and final tests indicate a certain changes, which can be seen by comparing these two measurements. We made this comparison in two parts as well as implementation of diagnostic tests itself. In the analysis, we looked at the results between initial and final tests for the evaluation of balance in one group of tests and results to evaluate the rhythm and coordination in the second group of tests.

7.1 Balance

Balance is defined as the ability to maintain a position with closed and open eyes, and oppose anti-gravity forces (D. Milanovic, 2006 y.)

It was tested in 4 different tests. Three of them evaluate static balance and one (fourth) test focused on evaluation of the dynamic balance. All tests have the same starting position on standing legs, while the differences are reflected in the positions of the free legs. Special emphasis is placed on difference in the fourth test where a free leg is successively changing position during the test, from forward to backward position and other way around.

The differences between the first three tests are reflected in one component (time), and the results are shown with measure of central tendency (mean), dispersion of results around the mean (standard deviation) and the percentage that shows increase or decrease of results. Looking at the results of the left and right legs there is significant improvement in all four tests. In the first test of left and right legs (Table 1, Graph 1, page 20), there were improvements for over 80% (80.2% R leg, 80.9% L leg) while in the second test results are(Table 2, Figure 2, Page 21) improved to over 60% (66.6% R leg; 62.4% L leg). The third test (Table 3, Figure 3, page 22) still took a visible difference in improvement between the right (84.9% R leg) and left leg (39.3% L leg). The fourth test was focused on assessing the dynamic balance, reflected at the two components (time and number of repetitions). And in both components, the results took a big improvement. In repetition (Table 4, Figure 4, Page 23) there are improvements for both legs over 200% (205.6% R leg; 211.5% L leg) while the measurement of time (Table 5, Figure 5; Page 24) shows improvement of over 150% (150.6% R leg; 159.4% L leg).

Still it should be noted that in the first three tests the standard deviation is reduced, while in the fourth test standard deviation is increased .

7.2 Coordination and rhythm

Coordination is a complex motor activity that can be defined as a motor intelligence, and present the ability to manage the movements of the whole body or individual parts of the locomotor system. According to (Drabik, 1996), coordination is the ability to fulfill the tasks of movement that require collaboration of more body parts without mental tension or errors and with minimal effort. A simplest description of

coordination is, the ability to perform simple and complex movements, ie. the capability of performing complex movements, and rapid learning of new movements also as fast changing from one to another movement. (Drabik, 1996).

The testing were performed in 4 tests on two different polygons. The first polygon is made of 8 straight set points in 4 different colors (red, yellow, blue and green) on the floor. While the other is made up of 4 different coloured points (red, yellow, blue and green) on the wall. At each polygon were conducted two different tests, initial and final, with a different tasks. And as in measured balance tests, there are improvements in the results of the final testing. Two tests on the first polygon are reflected in one component (time), and the results are shown with measure of central tendency (mean), dispersion of results around the mean (standard deviation) and the percentage that shows increase or decrease of results. While the second polygon is reflected with another component (the number of correct repetitions) and the results are also shown with measure of central tendency (mean), dispersion of results around the mean (standard deviation) and the percentage that shows increase or decrease of results.

The first test of coordination and rhythm was implemented by walking / running on points on the floor with a predetermined task. And results of the final test (Table 6, Figure 6, page 25) showed a faster passage of polygon for 20.7% then the initial testing. While on the same polygon in the second test (Table 7, Figure 7, page 26) with the given tasks during testing, the difference in speed performance is increased, for 47.7%.

On other polygon in the first test (Table 8, Figure 8, page 27) with a predetermined task. The number of repetitions are significiantly increased for 39,5%, just like in two first coordination tests. The same thing is reflected in the last one, most complex test of the battery (Table 9, Chart 9, page 28). And the improvement in the number of repetitions is increased for 20%.

8. CONCLUSION

On the analysis of the results we can conclude the following. The assumption that the balance and coordination is improving with this specific motoric program of rehabilitation for people with brain injuries, proved correct.

The results of all worked tests showed great progress of results in final testing. The most one we can notice is the development of balance while the coordination is slightly smaller. But it is quite understandable, because of the specificity of tests that evaluate the coordination.

Greatest thing is 200% progress in the last test for the evaluation of balance, especially with the fact that the frequency of the movement was also higher. If we consider, that every movement back and forth increases force and imbalance, especially if the speed/frequency of working is also increased.

Due to the specificity of such training/rehabilitation, it is also expected significant progress in the coordination of the measured persons. In fact, over 4,500 lateral movements per training, with the same number of movements and stabilization of trunk as well as with additional coordinating tasks for arms (with or without requisites), gave improved results from 20% to 50% in some tests of coordination.

We must point out that this measured group already attended the PRO SKI training before turning in this project (about 10 training sessions). And we can say that differences in result would be even greater.

Due to the slightly lower intensity and extensity of work and a little bit easier selection of exercises which is appropriate to the measured population. These results can also be generalized to the total population. As an activity that helps to improve motor and functional abilities, cognitive abilities as well as the prevention of stroke or heart attack.

9. LITERATURE

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10. INSET

1-st & 2-nd TEST RESULTS; BALANCE

	INICIAL TEST MB1 RIGHT LEG	FINAL TEST MB1 RIGHT LEG	DIFFERENCE	INICIAL TEST MB1 LEFT LEG	FINAL TEST MB1 LEFT LEG	DIFFERENCE	INITIAL TEST MB2 RIGHT LEG	FINAL TEST MB2 RIGHT LEG	DIFFERENCE	INITIAL TEST MB2 LEFT LEG	FINAL TEST MB2 LEFT LEG	DIFFERENCE
1	4	24,9	20,9	5,6	9,1	3,5	5,6	10,5	4,9	7,3	12,2	4,9
2	10	13,8	3,8	10	30	20	5,6	20,9	15,3	17,7	21,5	3,8
3	30	30	0	11	30	19	30	30	0	6,2	30	23,8
4	20	30	10	30	30	0	30	30	0	30	30	0
5	13,1	30	16,9	3,3	30	26,7	3	30	27	13,8	30	16,2
6	18,2	30	11,8	14,6	30	15,4	17,3	30	12,7	13,8	23,7	9,9
7	4,7	30	25,3	25	23,2	-1,8	18,3	30	11,7	30	23,3	-6,7
8	30	30	0	21,3	23,7	2,4	30	30	0	14,4	30	15,6
9	12,6	30	17,4	9,2	18,2	9	4,5	30	25,5	2,7	12,9	10,2
10	2,6	12	9,4	10,6	18,9	8,3	2,6	4	1,4	7,6	24	16,4
11	7,8	15	7,2	1,4	13,8	12,4	7,8	12,3	4,5	19,6	27,2	7,6

3-rd & 4-th TEST RESULTS; BALANCE

	INITIAL TEST MB3 RIGHT LEG	FINAL TEST MB3 RIGHT LEG	DIFFERENCE	INITIAL TEST MB3 LEFT LEG	FINAL TEST MB3R LEFT LEG	DIFFERENCE	INITIAL TEST MB4 RIGHT LEG TIME	FINAL TEST MB4 RIGHT LEG TIME	DIFFERENCE	INITIAL TEST MB4 LEFT LEG TIME	FINAL TEST MB4 LEFT LEG TIME	DIFFERENCE	INITIAL TEST MB4 RIGHT LEG REP	FINAL TEST MB4 RIGHT LEG REP	DIFFERENCE	INITIAL TEST MB4 LEFT LEG REP	FINAL TEST MB4 LEFT LEG REP	DIFFERENCE
1	3,8	23,8	20	6,52	8,9	2,38	4,8	12,4	7,6	6	10,8	4,8	4	10	6	5	9	4
2	5,3	18,7	13,4	12,6	22,5	9,9	6,9	22,9	16	6,8	30	23,2	5	19	14	5	30	25
3	17,5	30	12,5	30	30	0	7,8	25	17,2	10,9	30	19,1	6	19	13	8	24	16
4	30	30	0	30	30	0	18	30	12	23	30	7	7	23	16	10	23	13
5	13,4	30	16,6	4	30	26	5	26,8	21,8	10	15,6	5,6	4	19	15	6	10	4
6	14,4	23,1	8,7	11,4	16,6	5,2	7,7	11,3	3,6	10,4	20,5	10,1	4	7	3	8	15	7
7	30	30	0	17,9	15,9	-2	12	19,2	7,2	8,3	17	8,7	7	15	8	8	14	6
8	17	30	13	28,9	30	1,1	14,3	21,2	6,9	7,9	30	22,1	6	16	10	4	23	19
9	3,7	30	26,3	5,4	12,9	7,5	6,7	30	23,3	5	30	25	3	16	13	2	14	12
10	3,9	4,9	1	20,4	30	9,6	2,6	4	1,4	7,6	24	16,4	3	7	4	5	21	16
11	1	8,4	7,4	0	6	6	7,1	30	22,9	0	10,9	10,9	5	14	9	0	7	7

5-th,6-th, 7-th & 8-th TEST RESULTS; RHYTM, COORDINATION

	INITIAL TEST MRK1	FINAL TEST MRK1	DIFFERENCE	INITIAL TEST MRK2	FINAL TEST MRK2	DIFFERENCE	INITIAL TEST MRK3	FINAL TEST MRK3	DIFFERENCE	INITIAL TEST MRK4	FINAL TEST MRK4	DIFFERENCE
1	5,1	3,1	-2	18,9	12,2	-6,7	15	25	10	12	16	4
2	5,8	3,3	-2,5	7,6	4,9	-2,7	24	33	9	21	23	2
3	4,1	3,3	-0,8	7,5	4,8	-2,7	24	29	5	20	20	0
4	4,2	3	-1,2	26,7	3,9	-22,8	28	32	4	4	10	6
5	5,3	4	-1,3	18,2	8,7	-9,5	10	21	11	6	11	5
6	6,7	3,7	-3	12,4	8,7	-3,7	9	15	6	6	15	9
7	5,3	2,7	-2,6	7,4	7,4	0	21	32	11	18	20	2
8	4,6	3,3	-1,3	22,3	5	-17,3	36	43	7	20	18	-2
9	5,5	3,9	-1,6	12,3	8,3	-4	19	25	6	16	13	-3
10	5,1	4,9	-0,2	18,9	10,8	-8,1	15	30	15	12	17	5
11	18,9	20,8	1,9	41,8	26,7	-15,1	9	8	-1	5	5	0