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Application of Halliwick Method on Patients with Central Nervous System Disability with Examination of Functional Balance, Independence and Postural Assessment Scale

Thesis
abbreviated version

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1 Introduction

The primary goal of the therapy described in this article is the improvement of abilities related to self sufficiency in patients with central nervous system damage. Self sufficiency is based on the ability to perform functions that are impossible without balance and postural control.

Water was chosen as the medium of rehabilitation. Its various effects on the body can create such opportunities that cannot be taken advantage of on land, in the absence of the medium. Additionally, during the adaptation to the new environment, due to motor learning, open skills may develop.

The subject of my article is the assessment of the applicability and effectiveness of the Halliwick concept in patients with central nervous system damage, by keeping track of trunk control, reflected by balance and function.

2 Hypothesis

Stroke is the primary cause of chronic disability of adults, but few studies examine the motor activity of the trunk in affected subjects [Marcucci, 2007]. The assessment of trunk rose my interest mainly because, through reestablishment of postural control, the normalisation of trunk muscle tone and the restoration of muscle balance, i.e. proximal stability, provide the base for all distal movements.

Our goal is the fastest possible achievement of self sufficiency and independence, safe sitting and standing, and the promotion of change between these postures.

Mobilisation is fundamental in post-stroke rehabilitation, especially restoration of *function*. The base of function is the restoration of appropriate proximal stability, i.e. the coordinated static and dynamic functional ability to control the shoulder girdle, pelvis, and trunk [Kovács, 2003].

In recognition of these facts we decided to assess patients by measurement of activities of daily living (ADL), balance and trunk control.

We assume that self sufficiency and associated skills (Barthel-Index; BI and Functional Independence Measure; FIM) improve the same way as trunk control (Postural Assessment Scale for Stroke Patients, items 1 and 6–9; PASS-TC) and functional balance (Functional Reach Test; FRT), and the control data show improving trend compared to the data collected before the beginning of therapy.

2.1 Posing Questions

- Do our results, including Halliwick method in the therapy, compare to the results of international literature [Ching-Lin Hsieh, 2002; Benaim, 1999] that found significant improvement of PASS-TC in the early post-stroke period, in strong correlation with FIM values [Ching-Lin Hsieh, 2002]?
- Will the patients achieve results in the normal interval of FRT? How will it relate to function?
- Do the PASS values show changes even one year after stroke? What are these changes like? Do they change as significantly as in the early post-stroke period?
- How do the two ADL scales, FIM and BI, relate to each other?

3 Subjects and Methods

3.1 Introduction of Patients – General Description

Four persons were involved in the study, without restriction on gender and age, but only two of them could be assessed and treated due to time factor and lack of cooperation. These two persons took part of therapy based on Halliwick concept over 8 weeks, 2×45 minutes a week.

Their gender, age, height and weight were noted. Involved persons were male, average of 48.5 years, 181 cm and 77.5 kg.

Exclusion criteria in the selection were:

- Contraindications for application of aquatic therapy

Inclusion criteria in the selection were:

- Sign of acceptance statement
- Stay in the institute for at least 8 weeks, or participation in therapy at least for 8 weeks in case of outpatients.

3.2 Methods

We chose objective, trustworthy measurement methods. The measurement procedures aimed trunk control and balance, embedded into function. Data were recorded before and after therapy.

The following measurement scales were used:

- Functional Independence Measure Scale (FIM)
- Barthel-Index (BI)
- Functional Reach Test (FRT)
- Postural Assessment Scale for Stroke Patients (PASS)

Additionally, the following parameters were recorded:

- Duration of stay in the institute
- Instruments used to facilitate mobility
- Assessment of range of motion and muscle strength

The measurements and treatments were performed personally, in a well-lit, silent, placid examination room.

Several international and Hungarian studies discuss the validity and reliability of the measurement scales. We focused on measurement methods that are simple to perform yet provide exact results. This brought us to use these four methods.

Two scales were used to assess the activities of daily living. Its importance is the refined assessment of function with multiple points of view. The two scales (FIM and BI) intersect and complement each other. Putten et al. [1999] found that both measurement methods have similar sensitivity and has no advantage over the other one.

FRT was found beneficial due to various factors. It is simple, easy to implement and does not require expensive equipment. It is also reliable [Duncan, 1990], and is connected to function.

The ability to compare assessment data was taken into account as well. Results of Belgian researchers [Vereeck et al., 2006] underline a significant correlation among trunk performance, balance and abil-

ity to function. Correlation of FIM and trunk control is also proven by more studies [Franchignoni, 1997; Ching-Lin Hsieh, 2002]. Based on analysis of movement strategies Nagy [2002] stated that the value of FRT is primarily influenced by the flexional and rotational movement of the trunk and the pelvis strategy, and ankle strategy for a lesser extent.

3.3 Instruments

Halliwick therapy was performed in a pool of water with indifferent temperature (33°C) and a depth of 113 cm.

The pool can be approached in two ways. Since it is not sunken (outer height 130 cm) steps (*Photo 1*) or a hydraulic lift can be used by the patients.

Quality of the water was strictly monitored not to have high mineral content because it would've exerted the organs and influenced the effectiveness of the therapy. We used water with mineral contents of 0.3 g/l [Csermely, 2002].

In some cases rubber treaded shoes were used to create a fixed base of support.

Photo 1

3.4 Specific Case Description

Anamnesis

Peter N. is 64, was hit by a concrete beam on a building site. Current complaints: gait and sitting are uncertain, left arm and hand are awkward. Has no pain while being still, but has pain during passive mobilisation (extension) of left extremities.

Associate diseases: essential hypertension, vulgar psoriasis, spondylosis. These diseases are hereditary.

Peter currently lives in a self contained house that has stairs. He lives with his family who help him much. Inside he often uses a wheelchair as exclusive ways of movement but exercises 30–60 minutes daily with elbow crutches.

Diagnosis

He was brought to hospital as a severely damaged polytraumatic patient on 17/10/2006. Found right temporal cranial fracture, and opposite side frontal contusion that did not increase cerebral tension. Due to the closure of right arteria cerebris media the ischemic damage of same-side parietal lobe. Peter also suffered symphyseolysis and left pertrochanter fracture. He woke from coma on 20/11/2006. By this time quadriplegia has developed and he suffered from severe dysphasia. He was transferred to the National Institute for Medical Rehabilitation (OORI) on 18/12/2006, and returned home on 01/06/2007. He attends hydrotherapy 2×45 minutes a week as an outpatient. I joined his therapy and performed the first assessment on 28/11/2007.

Assessment

Peter's observation from the aspect of frontal plane yielded the following results: Left part of shoulder girdle is slightly elevated. Left shoulder joint is rotated inward. Elbow is in flexion, forearm in supine position. Wrist, finger and thumb joints are in flexion. Leftward lateral flexion of the trunk can be observed. From the aspect of sagittal plane: Left pelvic, knee and ankle joints are in extension, the right counterparts are in slight flexion. The trunk is slightly flexed.

During the muscle tone assessment both left extremities showed the "clasp-knife symptom", suggesting spasticity. The range of motion on the right side was appropriate for his age, but it was incomplete on the left side both actively and passively. The lower extremity is less degraded than the upper one. Muscle tone reflected the same results. Sensory assessment found surface anaesthesia at the distal end of lower left limb.

FRT was used to assess balance. The spasticity in Peter's left arm made it impossible to assess both sides. The measured value was 18 cm.

The result of FIM and BI scales reflected poor values primarily in the movement, transport and self sufficiency categories. According to PASS results Peter needs more or less help in execution of vertical movements.

Peter's motivation is outstanding; he is enduring, strongly cooperative. We set standing and confident gait as short term goals. Long term goal was the total abandonment of the wheelchair and the exclusive use of crutches. Additionally we aimed at the further resolution of spasticity to improve the function of the hand. His treatment is reduced to hydrotherapy from 01/01/2008 and the already set medication.

3.5 Observation in Water

"What and where is anything showing above water? Where is anything sinking?" [Gamper, 1995]

Peter's trunk was observed in sitting position. Active and passive mobilisation of shoulder girdle and upper extremities was essential part of his therapy. This was performed in sitting position, fixed with a seat belt at the pelvic girdle. This article is not concerned about this part of the therapy but it provided excellent opportunity to analyse sitting position. Pelvis is fixed in this posture and the compensation mechanisms of lower extremities do not interfere.

Photo 2

The longitudinal axis of the trunk deviates to the right from the symmetry axis, his head and gaze is aligned to the latter. The shoulder girdle is elevated, associated with slight protraction. This is more emphasised on the right side. Right shoulder is in neutral position. Left shoulder joint is spontaneously positioned in flexion, abduction and internal rotation. Slight right rotation of the thoracic section of the spine and left lateral flexion of lumbar section can be observed. Left side is shortened, right side is extended, and weight is borne on right side.

3.6 Application of the Ten Point Programme

Description of the Ten Point programme is not subject of this article. We find it important, however, to introduce the chosen method through case description because the practical implementation of TPP is a function of the patients' actual mental and physical state in all cases.

I. Mental Adjustment

Peter was not afraid of water from the beginning; he even prefers aquatic therapy. He acquired exhaling to water confidently with ease (*Photo 3*, *Photo 4*). This exercise helps establish and improve trust between patient and therapeutist that is essential in the future. Peter has extraordinary vital capacity. This gave him success in addition to good ability to float.

II. Sagittal Rotation Control

This is the first step to establish balance control. We can use it in therapy for active lateral flexion of the spine; it increases range of lateral flexional motion and extends the trunk. We can improve balance sideways, promote support and balance reactions and stabilise spine sideways [Barnai, 2003]. Increasing the range of lateral flexional motion and extension of the trunk were important in our cases.

Peter's motion is blocky, some selectivity could be observed only after several exercises, manifested in the form of lateral flexion on the non-laden, i.e. opposite side. (*Photo 5*)

III. Transversal Rotation Control

We practiced transversal rotation a lot for both patients. This demands acquiring a position that assumes significant trust towards the terapeutist.

This is the first exercise that changes vertical posture. The motion is a rotation around the transversal axis, i.e. lying supine from standing or sitting, and vica versa. It facilitates straightening, makes the fine tuning of trunk muscles possible due to continuous need for eccentric-concentric control.

Both patients had similar difficulties. At the beginning they started rotation from below, and they lacked the series of selective extension of spine sections, one by one. The therapy managed to achieve starting the rotation from above and gradual extension of the spine sections.

The PASS results reflect that Peter's therapy must focus on the motion patterns of vertical movements. Peter needs a lot of external support to perform the exercises (PASS 8–9).

IV. Longitudinal Rotation Control

Improved tone degrades, decreased tone improves the buoyancy of a given body part. In Peter's case (increased left-side tone) this would result in longitudinal rotation to the left.

The most important change to render the exercise more difficult is the decrease of radius around the longitudinal axis. This was achieved by drawing arms near the trunk, and closing lower limbs. Peter, due to the left side spasticity, did not succeed always in drawing his left arm near his trunk, but closing the lower extremities did not pose a problem.

Some blocky motion could be observed in Peter's rotation exercises initially, but it evolved into harmonic fine motion during continuous practice. He still needs help to turn towards unaffected side. This can be provided by the therapeutist from the affected side at the pelvis or at the shoulder girdle (*Photo 6*). Rotation to the unaffected side was easier when started from above. Rotation to the affected side was performed with equal ease both from above and from below.

V. Combined Rotation Control

It is essential for inhaling and exhaling not to restrict control to a rotation around a single axis, but during a complex exercise as well. Water adequate exhaling achieved during mental adaptation plays a primary role here.

It facilitates the spatial coordination of trunk and body, and has extraordinary functionality. This motion is the safe foundation of changing posture and location in water.

This exercise demands serious attention and concentration fromPeter. He often feels dizzy during these motions, and needs rela-

tively lots of external help. Continuous practice makes his motion more and more integrated, selective.

VI. Mental Inversion

Peter experienced that he cannot stay at the bottom of the pool for an extended period. He acknowledged the positive effect of upthrust. Continuous exhaling is important here as well, and we do not allow trials too long because of changes in pressure conditions.

Completion of the first six points assumes a great degree of independence that is a mandatory prerequisite of independent movement.

VII. Balance in Stillness

We focus on balance and stability of various postures. Patients must be able to react with central motor control; balance reactions must appear exclusively in the axial structure.

Any change of support provokes a balance reaction from the patient. The less the change the finer the coordination of muscle contraction that is necessary to maintain floating. This point is used to make the patient feel and practice the stabilisation and balance originating from trunk, pelvis, and the hip region.

Peter is affected on one side only. Due to the spasticity (on the left side) destroyed equilibrium of the two sides of the body. Increased tone degrades ability to float, so he would spontaneously rotate leftward around his longitudinal axis. Our goal is independent floating, without help.

Our primary goal for the patient is to learn how to maintain balance in an open kinetic chain.

VIII. Turbulent Gliding

This exercise is a more difficult version of point VII, i.e. we express massive forces around the body (e.g. turbulence).

Its relevance in therapy is the preparation of dynamic trunk balance. During the motion balance must be maintained “centrally”.

Peter had relatively much difficulty to perform this task the first time. Frequent practice and developed trust and cooperation came to a fruition of finding and, gradually, maintaining his balance in spite of turbulences and whirlpools we created.

IX. Simple Progression

This is a symmetric movement with arms held underwater all the time. If head and trunk control remained constant, then we would talk about the first true swimming position.

Arm movements disturb the trunk’s stability. This point may be better functionally than turbulent gliding.

Peter managed to maintain constant head and trunk control during symmetric arm movements, but it did not last long, only a couple of seconds. After having swayed off balance he managed to reestablish and maintain it again for a short period.

X. Basic Halliwick Movement

Peter did not reach this point by 01/02/2008 when my role in the rehabilitation ended. Our short term goals did not include the completion of the ten point programme; we aimed the confident control of water and the timely, exact, controlled adaptation to the effects of water. It is, however, a valid goal and his rehabilitation continues in this spirit.

4 Results

This section describes the results achieved. It is analysed in the function of time. Additionally, we compare our results to some internationally published data. The results are the achievement of all the people involved in the rehabilitation. The most important member of this team was the patient.

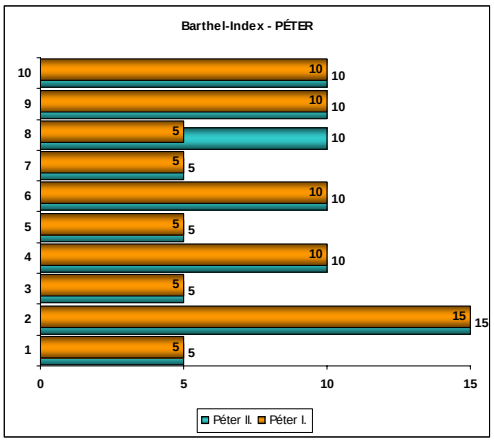

Chart 1 – Barthel Index

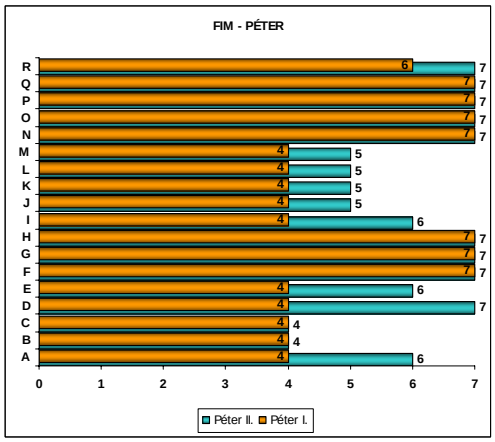

Chart 2 – FIM

The first two charts compare the initial and control values of FIM and BI. The values have improved. BI did not improve considerably, but FIM values show an improvement to be reckoned with. Apparently, according to BI Peter's activities improved only in "getting un/dressed", while FIM shows improvement in more areas. These are "eating", "movement" and "transport".

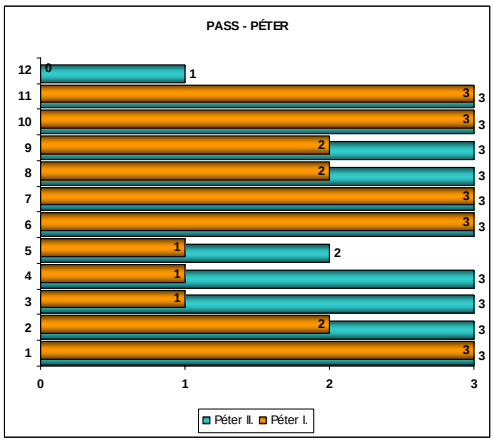

Chart 3 – PASS

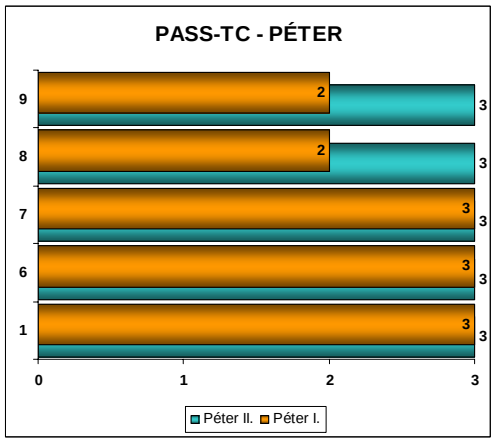

Chart 4 – PASS-TC

Chart 3 shows initial and control values of PASS. No negative tendencies can be observed. Peter received maximum score for five items initially, and ten items at control assessment. He still has potential to improve in "standing on affected lower limb" (item 5) and "pick up a small item from the floor while standing" (item 12), but even these two items have improved. It is important to emphasise that

there is an item that could not be performed at all by Peter initially, and he could perform it, even though with considerable support.

The items of PASS that are relevant to trunk control, based on the studies of Ching-Lin Hsieh et al [2002] are items 1 and 6–9. We took these as the base of our analysis. These items are:

1. Sitting without support
6. Supine to affected side lateral
7. Supine to non-affected side lateral
8. Supine to sitting up on edge of table
9. Sitting on edge of table to supine

The maximum score for these items is 5×3, that is, 15 points.

Peter (*Chart 4*) scored maximum for three of these elements even at the initial assessment, but control scores are maximal for all five items. He increased his initial score of 13 to the maximum available, 15.

One year has passed after the stroke of Peter before the initial assessment. His initial score was 67%. He scored 92% on the control assessment. We deduce that the improvement was significant, independently from the time of the stroke.

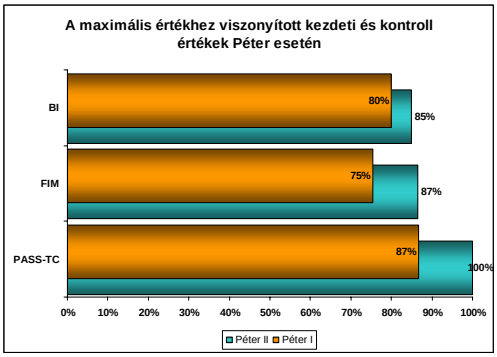

Chart 5 – Initial and control values compared to maximum, ADL and PASS-TC

Chart 5 compares trunk control (PASS-TC) to functional independence and self sufficiency (FIM, BI). Improvement can be observed in all three scales. Peter's BI improved by 5%, FIM improved by 12%, and PASS-TC improved by 13%. The values suggest that the three values are closely, but not linearly correlated. Of course this cannot be a general conclusion due to the low case count.

The normal interval of FRT is above 15–25 cm. Both patients achieved values than the lower boundary at the initial assessment, but they did not reach the upper boundary, unlike at the control assessment. Peter's FRT improved by 50%.

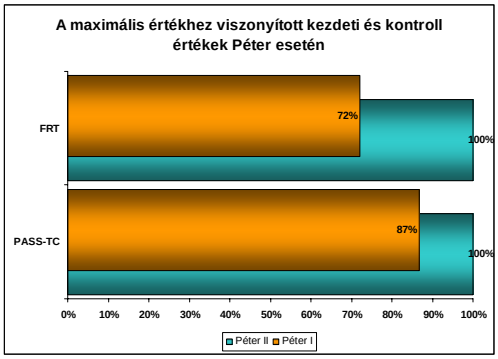

Chart 6 – Initial and control values compared to maximum, FRT and PASS-TC

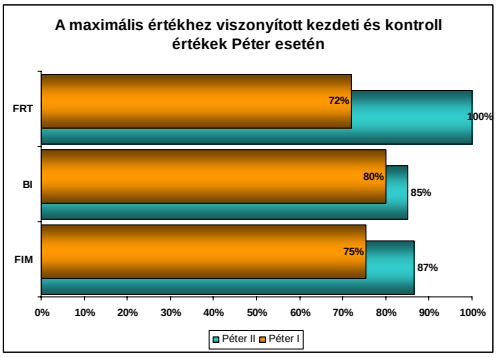

Chart 7 – Initial and control values compared to maximum, FRT and ADL

FRT control values exceeded 100%, defined as the upper boundary of the normal interval (25 cm). PASS-TC, on the contrary, has an absolute upper boundary (15 points). The two measurement methods are consistent, since both patients reached the maximum of PASS-TC and the upper boundary of FRT's normal interval. (*Chart 6*)

Similar to PASS-TC, FRT improved in significantly higher degree than the ADL measures. While FRT reached the maximum the ADL functions left measureable deficiency. (*Chart 7*)

5 Discussion

The ADL scales complemented each other, as assumed (3.2 Methods). Their scores were similar to each other (*Chart 1* and *Chart 2*). The actual abilities of the patients were not reflected in all areas. We found its root cause in the strict conditions and restrictions of scoring. Additionally, objective data was derived from subjective scoring in many cases (e.g. intense, moderate, slight support).

PASS results yielded the following: Peter's original score was 24 of 36 (*Chart 3*), of which PASS-TC was 13 of 15 (*Chart 4*). Control values show improvement, since complete PASS scored 33 of 36, and PASS-TC scored the maximal 15 of 15.

We find it important that both patients have reached the maximal score for trunk control. Additionally, PASS reached 91.6% for Peter and a similar excellent result for the other patient. Both patients found the item "Standing on paretic leg" the most difficult. This is, however, not surprising, since this is the hardest, most complex of the exercises when assessing static balance. Base of support is tiny, and the conditions demands appropriate muscle strength and coordination alike. Both patients had tone controlling problems as well that could not be dealt with by the end of the therapy. This is an important exercise from functional point of view. In Perry's midstance phase of gait the same demands are necessary, i.e. bearing the full body weight on one lower limb. This item has improved for Peter and stagnated for the other patient. As a side note we add that our part of the therapy, hydrotherapy, did not put emphasis on this exercise. We focused on improvement of trunk control instead, while land therapists endeavoured to perfect gait and the bearing of body weight.

Comparisons from functional point of view were made by correlating FIM and BI to PASS (see below).

Evaluating PASS-TC we can state that the possible best results were achieved. Peter's little initial deficiency can be explained by the time of the stroke and the continuous, frequent, adequate therapy applied (*Chart 4*).

Peter had problems with "Supine to sitting on edge of table" (item 8) and its reverse (item 9). Both belong to the upright (vertical) movements. They were improved primarily during vertical rotation and all combined movements based on that. Balance in stillness (step 7 of the ten point programme) and turbulent gliding (step 8) created such static and dynamic balance conditions that needed the finely harmonised work of all muscle groups, including the muscles responsible for vertical trunk movements, to maintain.

Evaluating full PASS we concluded that the test qualified as sensitive, independently from the time of the stroke. This opposes the results published in international literature [Ching-Lin Hsieh, 2002], but this cannot be generalised, since we studied only one case where one year had passed after stroke. Changes due to therapy were very

similar in both cases. Percentage-wise, control score improved by 25% in both cases.

Percentage increase of ADL values compared to PASS-TC values yielded likewise results (*Chart 5*). Scores increased in both cases, but not in equal rate. Our assumption that BI and FIM increases linearly with PASS-TC, did not hold. In Peter's case FIM and PASS-TC improved nearly the same rate, but BI improved much less. This may be explained by the inconsequent scoring of BI that does not reckon with marginal values.

We can conclude that our results partially match international studies [Ching-Lin Hsieh, 2002]. Both tests' scores improved, but the rates were not similar enough to claim a close correlation.

Comparing PASS-TC and FRT results the following correlation can be observed. Peter's initial PASS-TC score was close to maximum, thus the improvement was not so outstanding (13%). Regarding FRT (defining 25 cm as 100%) improvement was 36% (control value of 108%, not shown by charts) and it can obviously be measured. Therefore we concluded that, in Peter's case, PASS-TC was not as sensitive as FRT (*Chart 6*).

Comparing FRT and ADL scales we can state as well that in Peter's case, due to the high initial scores, the improvement that can be measured by ADL scales is not as evident as for the other patient. FRT has changed in the same direction but for a different degree (*Chart 7*).

All in all, we can state that functional balance and trunk control improved for a greater degree than abilities used in activities of daily living. Thus, former measures only forecast the latter ones. Complete PASS, on the other hand, shows an overall picture.

The changes in range of motion and muscle strength were in positive direction in both cases. Peter had initial values deviating from normal on the unaffected, right side in addition to the affected left side [Kapandji, 2006]. The former showed changes on the proximal section of the upper limb; range of motion improved there. On the proximal section of the left upper limb and in the full length of the left lower limb improvement both in muscle strength and range of motion can be observed. Observing the trunk we saw significant changes in lateral flexion and rotation. Former increased by 125% on right side and by 150% on left side. Rotation became equal (20°) on both sides, reflecting an improvement of 133% on right and 200% on left side. Flexion and extension muscle strength was level 4 on control assessment. This matches the initial value on right, and exceeds the initial value of 3 on left side.

The following results reflect the harvest of our work best:

Peter spent his everyday life in his wheelchair in November 2007. In contrast, nowadays he uses the crutches more than the

wheelchair. By his own admission he climbed 5 stairs independently up and down. On 01/02/2008 he climbed the pool stairs alternating his legs. Downwards he still had problems with alternated gait. He is able to fetch books independently from shelves over breast height at home. He is able to stand in the kitchen without support and peel potatoes.

The success of therapy and effectiveness of Halliwick concept are best demonstrated by these results.

6 Conclusion

We studied patients with cerebrovascular insult in this article, and treated them according to Halliwick method. We examined functional independence, abilities of self sufficiency and balance. The objective scales at our disposal were simple, demanded little time and low cost to apply. Assessments were made at the times when I joined the rehabilitation and when I left the team. Rehabilitation of patients is continued afterwards.

Patients received comprehensive therapy. It includes medication, movement therapy and ergotherapy alike. Movement therapy has two large parts, basic and supplementary ones. Basic movement therapy is performed on land, while the treatment is made complex and comprehensive by the supplementary part; hydrotherapy. The Halliwick concept is organic part of hydrotherapy, but other, aquatic therapy methods were used in addition to address specific problems. We find it important to notice that the results achieved are not exclusively results of our job. We were members of a rehabilitation team; therefore the results reflect the complete work of the whole team.

In my opinion we managed to improve abilities to perform functions significantly, and improve some functions to skill level.

We had opportunities in water that couldn't have been established on land. Such a condition is the lack of fixed base of support, making it possible to easily change its size and direction, giving an unbound instrument to the therapeutist. By changing base of support the aid can easily lead the patient to find and lose balance. This is the essence of improving balance. In addition, buoyancy helped to perform such normal movements that could not be achieved on land. This stimulated the central nervous system with appropriate input.

I think that we aided the patients much in performing activities of daily living, self sufficient and independent lifestyle, and raise their standards of their life to a higher level.

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8 Appendix – Additional Photos

Photo 3

Photo 4

Photo 5

Photo 6