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Cyclic movement training of the lower limb in stroke rehabilitation

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Abstract

Besides neurological impairments, stroke causes above all immobility that may lead to secondary diseases. In addition to conventional physio- and ergotherapeutic intervention which is normally experienced by stroke victims, this study examined the effects and benefits of a home-based training with a MOTOmed Movement Trainer.
Study design: Out of 31 patients, an experimental group consisting of 16 patients (age: 63,1 ± 8,1 years) was supplied with a MOTOmed viva2 Movement Trainer (RECK-Medizintechnik, 88422 Betzenweiler, Germany). They were adviced to train twice a day for 4 months in addition to their conventional therapy. The intensity of each training session corresponded to stage 13 on the BORG-Scale ("a little strenuous"). Primarily, the influence on gait was proved measuring gait velocity and the distance walked in the 2- and 6-Minutes-Walking Test. In addition, motoric assessments were used (Tinetti-Test, Berg-Balance-Scale, Timed "Up&Go"-Test). MOTOmed Data was collected by a chipcard placed in the cockpit of the apparatus. The patients of the control group (n=15, age: 65,8 ± 10,7 years) received conventional physio- and ergotherapeutic interventions.
Results: The results of this study showed an improvement in walking distance (2- and 6-Minute-Walking test; p=0,015, p=0,003), comfortable gait speed (p=0,024) and better results concerning timed "Up&Go" Test (p=0,016). Furthermore, patients were able to steer their training by using the Borg-Scale so that they achieved an average power increase of 6,3W of (p=0,009).
Conclusion: Using the MOTOmed Movement Trainer is a helpful addition to conventional therapy and supports an active participation in the rehabilitation process of stroke patients.

Keywords: Stroke rehabilitation, movement Trainer, Gait

Introduction

Currently, 800.000 people live in Germany who suffer the consequences of stroke [1, 62]. The incidence amounts 182/100.000 habitants, respectively 150.000 new strokes every year. In addition, yearly 15.000 recurrent strokes occur [18]. Only about 20% of the survivors recover to the extent of living on without any handicap. Altogether, 64% of the victims who survive the first year after stroke (about 100.000) rest in need of care. The part of stroke victims who die or suffer heavy neurological deficites becomes smaller and smaller because of better and faster medical supply. But there is a strong need to offer an enduring therapy to those who are able to come back into their home environment. Besides therapy of primary neurological impairments, the aim of such interventions is a minimization of secondary diseases caused by immobility. The consequences bear on both, musculoskeletal (e.g. muscleatrophy, osteoporosis caused by inactivity, contractures) and cardiovascular system (e.g. minimized VO2max.), and a diminished aerobic endurance means a handicap in handling activities of daily living [21, 61]. It is assumed that cardiovascular consequences which occur due to immobility after stroke being a bigger handicap than the neurological impairment. Because the survival rate of stroke victims is very high [49, 60] cardiovascular diseases pose the most commonly accruing cause of death [54, 55].

For this reason one approach of sustained rehabilitation has to be an increase of the offer of exercise therapy. Such interventions should be accomplishable during a non-therapy term concerning physio- and ergotherapeutic interventions.

As in traditional sports training, we can assume that also in the rehabilitation of stroke, motoric attributes can be improved [12]. Several studies approved trainability of stroke patients and documented resulting physical and psychological effects [13, 14, 35, 41, 52, 53]. Furthermore, other studies evidenced effectiveness of a more intensive rehabilitation programme, e.g. by using a treadmill in addition to conventional therapy interventions [24, 37].

In literature, an often used term concerning movement training in stroke rehabilitation is "task-related training" [10, 13, 37], in case of the present study concerning stroke rehabilitation, it means motion sequences to improve strength, coordination and flexibility of the patient's affected leg to improve gait.

The present study examined the effect of a training for four months with a MOTOmed movement therapy system (MOTOmed Bewegungstherapiegeräte, RECK-Medizintechnik GmbH & Co. KG, Reckstrasse 1-4, 88422 Betzenweiler, Germany) and its benefits in stroke rehabilitation. The german health insurances have been covering the costs for the MOTOmed system since 1988. It has to be viewed as useful, self dependent addition to conventional physio- and ergotherapeutic interventions. This way, the patient is given an opportunity to participate in his own rehabilitation process and promoting his treating doctor and therapists in terms of an optimal rehabilitation result. The application of the MOTOmed ranges from passive motion to assistive motion to active training. This is possible due to a servo-electric motor. Irrespective of the mode of motion, the MOTOmed allows a very great number of repetitions. By reason of the coherence of afference and efference, repetitive processes and great numbers of repetitions are considered to be eminently effective concerning the use of the central nervous system's plasticity [12, 27].

Because stroke is the leading reason of gotten long-run- and gait disability, attention was turned on the motor activity of the lower limb. In stroke rehabilitation motor activity of the lower limb poses an important component of regaining gait, expanding activities of daily living and thus self-determination and participation of stroke patients. This should be a therapy goal in all phases of the rehabilitation [27]. Indeed many patients are able to walk without assistance, but lack of gait speed and diminished endurance, which means high metabolic costs, lead to exhaustion compel them to stay more and more inactive [13, 35, 40]. Only 7% of the outpatient stroke victims are able to walk 500 metres continuously keeping/sustaining a speed that ensures crossing safely a street with traffic lights. [25]. Furthermore many patients are afraid of falling due to lack of walking ability. One study could show that the six-month incidence of falls due to stroke was 73%. 47% of the researched subjects fell more than once, 24% were not able to stand up on their own after they fell [20]. For this reason, one should recognize that when offering possibilities to stroke subjects to train on their own, these interventions should be safe.

The aims of a MOTOmed exercise training can be verbalized as follows:

1. Compensation of immobilisation
2. Countering secondary impairments and recurrent strokes
3. Improvement of physical fitness
4. Encouraging patients to be a part of their own rehabilitation process.

The aims of this study were:
1. Proving the effectiveness of training with a MOTOmed movement system: In comparison to a control-group, were patients who trained with a MOTOmed for four months able to improve their results in asked motor tests?
2. Proving the effectiveness of steering training with the help of the BORG-scale: Was it able for stroke patients to steer their own training intensity with the help of the BORG-Scale?
3. Proving therapy compliance: Did the patients use the MOTOmed as regularly as they were told to?

Patients and methods

Over a time period of 5 months, we were able to recruit 40 patients. The recruitment was done in 3 stationary rehabilitation centres (Godeshöhe Bad Godesberg, RehaNova Köln-Merheim, Eifelhöhenklinik Marmagen) and 2 outpatient rehabilitation centres (Neurologisch-interdisziplinäres Behandlungszentrum NIB Köln und Neurologisches Therapiezentrum NTC Köln).

All subjects conformed to the *following criteria*:
1. Stroke with resulting hemiparesis
2. Handicap of walking as a result of stroke, ability to walk with supervision and/or with aids >10 metres.
3. Ability to understand instructions
4. Living at home

Exclusion criteria were determined as follows:
1. Sanitary constitution, which would make a sub maximal training impossible.
2. Pain that inhibits training with the MOTOmed.
3. Ability to use a normal cycle ergometer.

Drop out
Because of sanitary and/or organisational reasons, 9 patients dropped out of the study so that we were able to receive data from 31 patients.

Application flow/ Tests
The project was proved by the ethnic commission of DSHS Cologne and it was accepted.
In inpatient centres, released patients who accomplished inclusion criteria (as far as available from the database of each rehabilitation centre) were informed about the study. Normally, the population of patients consisted of phase c patients. In outpatient rehabilitation centres, applicable patients were informed on location.

	Number (♀/♂)	Age (years) (Mean ± SD)	Months since stroke (Mean ± SD)	Ishemic/ Hemorrhagic	Paretic Side (left/ right)	Therapy frequency per week Phys./Ergo
IG	16 (11/5)	63,1 ± 8,1	12 ± 9,5	16/0	9/7	2,1/1,8
KG	15 (11/4)	65,8 ± 10,7	15,4 ± 12,1	15/0	7/8	2,1/1,9

Tab.1: patients' data (IG= Interventional group, CG= Control group)

All in all 250 patients we addressed. Of these 250 patients, 40 patients agreed to join the study and signed a declaration of consent. Hereupon, a date was arranged to do the baseline tests at the DSHS Cologne.
The selection of the tests was done by reviewing them to be reliable, valid and showing age- and disease-specific norms as well as practicability. Primary important variables were the results of testing patients' comfortable, "normal" gait speed, maximum gait speed as well as the distance walked in 2 and 6 minutes walking test (2/6MWT). Secondary variables were results of timed "Up&Go" – test, Tinetti-test and Berg-Balance scale.

Test procedure was arranged as follows:
1. Tinetti-Test
2. Berg-Balance-scale
3. Timed "Up&Go"-Test
4. 10-Metre-Test
   (1. comfortable, 2. maximum gait speed)
5. 2/6 minutes walking test

1. Tinetti-Test

The Tinetti-Test determines mobility related disorders and lights up risks of falls in older subjects [58]. On the one hand, balance is tested, on the other hand gait is evaluated with the help of an ordinal scale (0-1, respectively 0-2). Score ranges from 0 to 15 concerning balance and from 0 to 13 concerning gait. A score of 20-27 means a small probability to fall. Mobility is restricted and the probability of falling is increased when reaching a score of 15-19. A score of 0-9 means a massive restricted mobility and risk of falling is very high.

2. Berg-Balance-scale (BBS)

The Berg-Balance scale measures patients' ability to manage 14 tasks which require balance as it is required in everyday life. The test begins with easy tasks (e.g. sitting free) and ends with more difficult tasks (e.g. standing on one leg). Assessment was done by using an ordinal 5 points-scale (0-4), whereas the all-up number of score ranged from 0 to 56. Aids (e.g. canes) were not allowed.

3. Timed "Up&Go"-Test (TUG-Test)

The timed "Up&Go" test measures the time needed to stand up from a chair with armrest (seat height 46 cm), going around a pylon who stands 3 metres away from the chair, walking back and sitting down to basic position. (Basic position means: The patients back is completely positioned at the backrest.) Only then the time was stopped. The procedure was demonstrated once to the test person. Aids were allowed, if needed. Patients are considered to be able to life independently, when they can manage to solve the task in less than 10 seconds [48].

4. 10-Metres-Test (Gait speed)

With this test we wanted to test patients' gait speed. To eliminate influences of acceleration and deceleration, the time to walk 10 metres was measured in the middle of a 14 metres walkway. Test persons had to walk 3 metres to get to the start position were measurement begun. To avoid a deceleration before the 10 metres mark, patients were asked to walk to a mark one metre behind the finishing line. Measurement was carried out two times demanding patients to walk with their comfortable, normal walking speed and two times demanding them to walk with their maximum walking speed. The average value of both measurements was decided to be the gait speed in m/s. The time was measured with a hand-held stopwatch. Aids were allowed, when necessary.

Fig. 1: Patient with MOTOmed movement therapy system

5. 2/6 Minuten Walkingtest (2/6MWT)

The 2/6 Minutes Walking test (2/6MWT) was used to measure maximum walking distance of the patients in a given time. Originally, this test was used to bring out physical fitness in cardiologic patients [22], in the meantime this test is established in assessing physical fitness of neurological patients. Patients were asked to walk around a rectangle (18 m length, 9 m breadth) as often as they were able to in 6 minutes. They were allowed to have breaks if they needed to, but time went on. After having walked for 2 minutes, the distance was marked. Aids were allowed if needed.

Intervention

After randomized assignment to an interventional- and a control group, interventional group subjects received a MOTOmed MovementTherapySystem (RECK-Technik GmbH & Co. KG, Betzenweiler, Germany) for four months. The MovementTherapy System can be seen as a kind of bicycle ergometer that can even be used by non-ambulatory patients.

Because of restricted balance, many patients show missing stability of the upper part of the body. So they are not able to train on a conventional ergometer cycle. Compared to a normal ergometer, the MOTOmed offers to train with very easy gears. With the help of a servo electronic, even very little power produced by the paretic limb can lead to a movement. Furthermore, passive movements of the lower limbs are possible to relax spastic muscles and keep the joints flexible. To keep especially the paretic leg in the right position and avert an abnormal movement, feet and lower legs can be fixed to the apparatus. In case of beginning spasticity during the movement, the MOTOmed system detects the unusual tonus, stops forward movement and induces a reversal movement (principle of antagonistic inhibition).

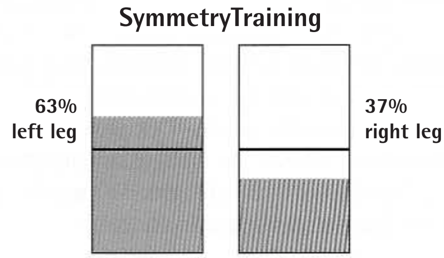

Fig. 2: Display of symmetry of the MOTOmed

The apparatus is equipped with a display, which gives feedback to the exerciser concerning duration, repetitions per minute, power, distance and symmetry. (Symmetry means a comparison of inserted power of the right and left leg in %). The display of symmetry makes it possible to percept the power produced by the paretic limb.

Frequency of training, average power, repetitions per minute, as well as duration of training session and distance were stored on a chip card placed in the cockpit of apparatus after each training session. The training took place at the patients' home. They were only asked to train twice a day with a period of at least 10 minutes active pedalling. Before and after this active pedalling phase, patients were told to do a warm-up and a cool down for a time period of about 2-3 minutes. This exercise frequency is proposed by GORDON and coworkers (2004), too with regard to an endurancetraining with stroke patients [21].

In addition patients were told to pedal with 50-70 repetitions per minute [46] and to turn their attention on the symmetry display to get feedback about the activity of the paretic leg. The intensity of each training session corresponded to stage 13 on the BORG-Scale ("a little strenuous") whereas the classification of the Borg-scale reaches from 6 ("very, very easy") to 20 ("very, very hard"). Usually, stage 13 is declared to do moderate endurance training. The Borg scale has to be seen as an additionally used diagnostic method to assess the extent of exertion and is often operated with in clinical studies [9]. Especially in cardiologic rehabilitation this method is often used [28, 34]. To avoid a stagnation of physical fitness during the training period, patients were explicitly told to adjust the intensity of training according to the improvement of their physical fitness due to the training. According to the guidelines of motoric rehabilitation, an increase of exercise time was desired [27]. A sports scientist was at the patients' disposal to show them all functions of the MOTOmed, the right seat position and to adjust the baseline training resistance. This way, the baseline load corresponding to individual physical fitness depending on severity of impairment was adjusted. Patients were phoned every 14 days to receive feedback and solve problems to potential problems. During this training period, the control group received conventional physio- and ergotherapeutic interventions.

Statistics

Statistical calculations were done by using SPSS 12.0 computersoftware. Level of significance: α=5% (p=0,05). To calculate statistics of motoric assessments, analysis of variances (ANOVA) was used. If significant interaction was present (p>0,05) between interventional- and control group, a paired t-Test was calculated.

To prove if the intensity of MOTOmed training (first training) fits to patients' physical fitness pearson's correlationcoefficient was used. To control patients' steering of training in terms of exercise-specific parameters (e.g. duration, power, pedal frequency) that had an influence on the parameter "distance", t-test was used.

Results

Motoric tests

Though motoric capacity varied within both groups, one can say that both groups were uniformly distributed i.e. before examination period there were no significant differences concerning patient characteristics (as shown in tab.1) and motor capacity between interventional- and control group. After four months there were significant interactions between both groups regarding 2/6MWT (p=0,015, p=0,003), comfortable walking speed (p=0,024) as well as the timed "Up&Go" test (p=0,016). No significance was detected regarding Tinetti-Test (p=0,313), Berg-Balance scale (p=0,1) and maximal walking speed (p=0,188). Using paired t-test, 2/6MWT, comfortable walking speed and timed "Up&Go"-test showed significant results in favour of the interventional group respectively non-significant results for the control group.

MOTOmed movement training

To get an overview on the data from the MOTOmed

	INTERVENTIONAL GROUP			CONTROL GROUP			Interaction
	Test (Mean ± SD)	Retest (Mean ± SD)	P_{IG}	Test (Mean ± SD)	Retest (Mean ± SD)	P_{KG}	$P_{Interaktion}$
Tinetti-Test	22,69 ± 3,79	24,19 ± 3,27	n.s.	21,27 ± 5,06	22,07 ± 4,61	n.s	n.s.
Berg-Balance-Scale	41,31 ± 8,58	45,75 ± 8,48	n.s.	37,53 ± 10,62	39,4 ± 11,82	n.s	n.s.
TUG (s)	29,06 ± 18,27	22,18 ± 14,03	0,013	26,98 ± 14,83	26,81 ± 14,75	n.s	0,016
10 m (normal) (m/s)	0,53 ± 0,24	0,65 ± 0,29	0,002	0,55 ± 0,24	0,58 ± 0,25	n.s	0,024
10 m (fast) (m/s)	0,68 ± 0,37	0,84 ± 0,41	n.s.	0,69 ± 0,34	0,75 ± 0,35	n.s	n.s.
2-MWT (m)	65,7 ± 31,25	79,85 ± 37,76	0,001	67,96 ± 27,83	70,13 ± 29,18	n.s	0,015
6-MWT (m)	188,28 ± 94,44	237,84 ± 115,66	0,001	194,01 ± 85,94	195,29 ± 88,25	n.s	0,003

Tab. 2: Test- and retest results of interventional and control group (Mean ± SD), (α=5%, n.s.= non significant). Paired t-test results (P_{IG}; P_{KG}), innersubject effects ($P_{Interaktion}$)

Week 1	Power (W) Mean ± SD	Duration a. (min) Mean ± SD	Duration p. (min) Mean ± SD	Distanz a. (m) Mean ± SD	Distanz p. (m) Mean ± SD	Pedalling frequence (rpm) Mean± SD
1	16,56 ± 6,40	15:32 ± 6:10	02:02 ± 2:00	3.387,54 ± 1.924,88	130,15 ± 144,54	57,34 ± 6,83
2	17,14 ± 7,60	16:04 ± 6:15	02:34 ± 2:48	3.348,04 ± 1.465,70	160,45 ± 177,88	57,77 ± 9,80
3	17,27 ± 8,16	15:31 ± 6:19	02:23 ± 2:23	3.327,60 ± 1.415,84	155,57 ± 166,83	57,17 ± 11,54
4	17,64 ± 8,63	14:42 ± 5:47	02:29 ± 2:25	3.221,34 ± 1.335,56	159,36 ± 169,99	57,24 ± 12,10
5	18,80 ± 9,16	15:37 ± 5:59	02:32 ± 2:40	3.515,06 ± 1.315,79	156,74 ± 177,28	58,14 ± 12,00
6	19,62 ± 9,76	15:19 ± 5:55	02:30 ± 2:58	3.596,68 ± 1.389,44	152,16 ± 174,63	58,86 ± 11,21
7	20,15 ± 9,36	16:20 ± 6:08	02:29 ± 2:49	3.981,23 ± 1.708,47	155,08 ± 183,37	59,10 ± 10,92
8	20,15 ± 9,09	15:51 ± 5:23	02:43 ± 3:15	4.037,10 ± 1.857,71	166,39 ± 194,34	58,44 ± 9,67
9	20,56 ± 9,47	15:48 ± 5:03	02:44 ± 3:21	4.035,93 ± 1.819,93	170,55 ± 202,91	58,69 ± 10,85
10	21,56 ± 9,57	15:15 ± 4:38	02:22 ± 2:49	4.066,79 ± 1.714,36	142,58 ± 158,94	59,41 ± 10,14
11	21,04 ± 9,81	14:55 ± 3:40	02:32 ± 3:15	3.971,42 ± 1.706,99	148,29 ± 170,18	58,88 ± 10,33
12	21,89 ± 10,58	16:08 ± 4:34	02:38 ± 3:10	4.365,71 ± 2.006,92	146,51 ± 168,14	58,79 ± 11,26
13	22,67 ± 10,62	15:12 ± 5:05	02:37 ± 3:03	4.320,97 ± 2.262,60	160,03 ± 184,69	58,69 ± 10,68
14	22,42 ± 11,62	15:17 ± 5:23	02:39 ± 3:28	4.275,80 ± 2.197,49	158,95 ± 189,86	57,88 ± 9,34
15	22,28 ± 10,64	15:35 ± 4:53	02:36 ± 3:08	4.404,62 ± 2.059,54	154,08 ± 178,23	57,27 ± 8,96
16	22,59 ± 11,16	16:30 ± 5:25	02:36 ± 2:58	4.715,86 ± 2.288,92	156,94 ± 182,99	57,06 ± 9,19

Tab. 3: Average exercise values (Mean ± SD) Week 1 to 16

	First week	Last week	t-Test
Duration active (min)	15:32	16:30	p = 0,23 (n.s.)
Duration passive (min)	02:02	02:36	p = 0,211 (n.s.)
Distance active (m)	3.387,54	4.715,86	p = 0,027
Distance passive (m)	130,15	156,94	p = 0,256 (n.s.)
Power (W)	16,56	22,59	p = 0,009

Tab. 4: Average exercise values week 1 and week 16, t-test (n.s. = non significant)

chip cards, these data were put together in weekly periods and averaged. The following parameters were regarded: Power (watts), average duration of exercise (pedalling active), average distance (pedalling passive) and revolutions per minute (Tab. 3 and 4).

Duration of exercise stayed almost unchanged, just as revolutions per minute. Therefore, an increase of distance was done by changing into higher gears, and this means pedalling with higher resistance. This concludes that reaching a higher gear-level was more important to the patients than increasing duration of pedalling. This conclusion is also evidenced by a high correlation between the two parameters (r=0,948, Fig. 6), respectively a non significant correlation between distance and revolutions per minute (r=0,211) and between distance and duration of exercise (r=0,357). With regard to the parameters "distance passive" and "duration passive", very high standard deviations can be recognized. We can assume that many patients did not use the passive function and therefore started pedalling active from the beginning, even though they were told to use this mode in the sense of warming up and cooling down. The results of the t-test to compare between first and last week of intervention show significant improvements in case of distance (p=0,027) and power (p=0,009) (Fig. 6).

Concerning duration of active pedalling, there was no significant improvement (p=0,23).

To prove, if patients with a higher motoric capacity (as measured with the 6MWT) trained with higher

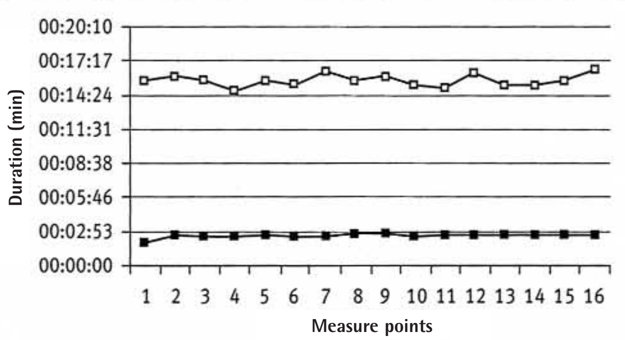

Fig. 3: Average duration of exercise (❑=active, p=0,23/ ■=passive, p=0,211) during interventional time of 16 weeks

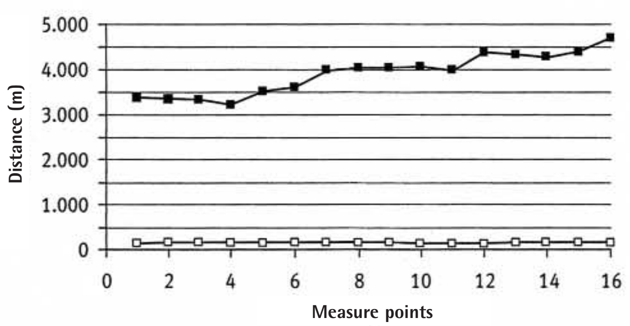

Fig. 4: Average distance active (❑; p=0,027), average distance passive (■; p=0,256)
(distance active= (watts x time) / factor x)

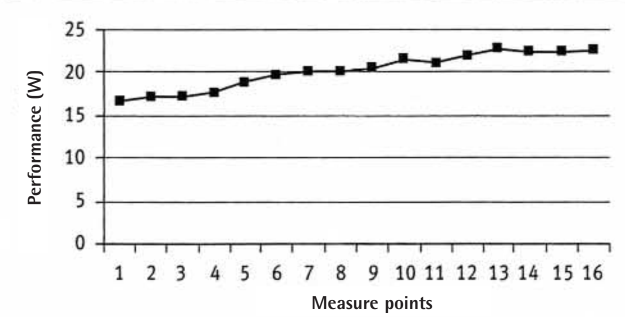

Fig. 5: Average power (p=0,009) weeks 1-16

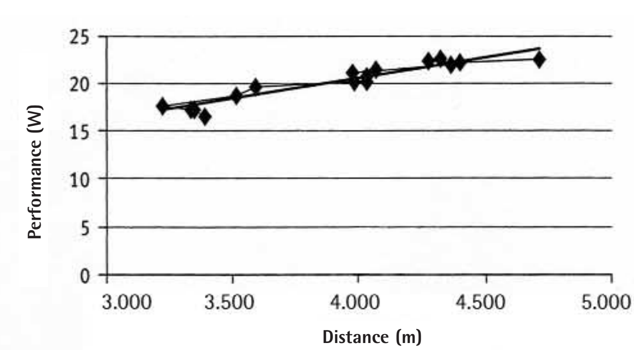

Fig. 6: Correlation power/distance (r=0,948) weeks 1-16

workloads when exercising with the MOTOmed system (as measured through average power), an examination on linear coherence between the results of the baseline result of 6MWT and the average workload in week 1 was done. We assumed that patients who were able to walk a longer distance in 6MWT would also be able to train with higher workloads when doing MOTOmed exercise. As Fig. 7 shows, walking distance in first 6MWT an average workload in week 1 correlated (r=0,72). So we can assume that entry-workload was adjusted on the patients' motor abilities.

On average patients in interventional group did 205,1 ± 55,8 training sessions as well as 3019 exercise minutes (active pedalling) during intervention time.

Discussion

The present study proved the effectiveness of a four-months training intervention with a MOTOmed movement system concerning an improvement of lower limb motor function. Stroke patients were told to train 16 weeks, twice a day for at least 10 minutes per session. Because an improvement of endurance cannot be expected in a shorter time period [61] and due to the fact that we had to calculate unaccepted missing time/ time debits (e.g. because of illness) the duration of the interventional period was suitable/ appropriate. Before and after this intervention motor tests as well as standardized walking tests should detect changes. The main results showed improvements in walking distance (2/6 MWT), comfortable gait speed and timed "Up&Go" test. Concerning motor assessments (Tinetti Test, Berg Balance Scale) and maximum gait speed, there were no statistical differences between interventional and control group.

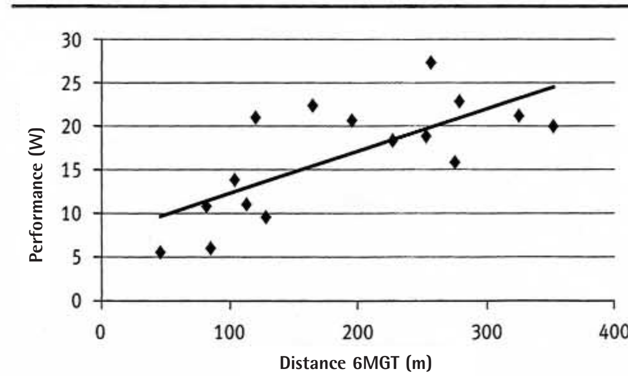

Fig. 7: Correlation of MOTOmed workload (week 1) / distance walked in first 6MWT (r=0,72)

Though there was a wide range in physical capacity of the participants of the study, both, interventional and control group were uniformly distributed by randomization. No difference was determined concerning frequency of physio- and ergotherapeutic interventions, too.

But we were not able to have an influence on the quality of these therapeutic interventions, which usually depends on the quality of the treating therapist. Of course, this quality can have an impact on the results of the tests. However, this is a common problem in rehabilitation research, also in this study [23, 32].

Motor assessments

The Tinetti test and Berg Balance Scale did not show any improvements of the interventional group compared to the control group. Regarding mean values, both groups indicated an improvement. The Tinetti test was viewed in general result. That means the results of part 1 "balance" and part 2 "gait" were added. But we have to take into consideration a ceiling effect. The highscore of the Tinetti Test is 28. In the first testing interventional group showed a mean value of 22,69 ± 3,70 and 21,27 ± 5,06 for the control group. Therefore only little improvements were possible to reach highscore.

Also Berg Balance scale showed no significant interaction between the two groups (p=0,1). In a study with stroke patients, STEVENSON et al. (2001) found out that there has to be a difference of at least 6 points between test and retest so that the difference becomes significant [56]. In the present study, changes were found below this limit (with a smaller patient population!). For this study, perhaps the chosen motor assessment tests were not sensitive enough to point out changes that occured due to the MOTOmed training.

BATEMAN and coworkers (2001) found out that an improvement in ergometer cycling had no impact on mobility in brain-injured patients. [3]. In this study one group did a twelve-week ergometer cycletraining and another group practiced a relaxation training. Participants of the cycling group showed an improvement in workload concerning ergometer cycling. But when testing "physical function" as assessed with Berg Balance scale and gait speed (10 m) there were no statistical differences between both groups.

In our study, especially statistical results of Tinetti test and Berg Balance scale showed that a movement training with a MOTOmed system cannot change some everyday-life abilities in stroke patients, respectively potential changes could not be depicted using these ordinal scales. Nevertheless the timed "Up&Go" test that measures independence and basic motor abilities (e.g. getting out of bed, of a chair or a toilet and making some steps) (30) showed significant results (p=0,013).

Walking tests

In literature, independence and autonomy are often detected/measured with gait speed and walking distance. PERRY et al. (1995) observed a connection between Impairment, disability and handicap in 147 stroke patients [45]. They found out that a gait speed of at least 58 ± 18 cm/s is needed to participate with restrictions in community living without the assistance of a wheelchair. Independence is associated with a gait speed of at least 0,8 mm/s, safely crossing a street with traffic lights with a gait speed of at least 1,2 m/s. Similar results were found out by HOXIE et al (1994) [26]. According to a study by ENRIGHT and SHERRILL (1998) the average 6 minutes walking distance in healthy men (n=117, age=59,5 years) is 576m, in healthy women (n=173, age=62) 494 [17]. A minimum distance of 332 metres and 80 m/min (1,33m/s) is required. [39]. Other investigations discovered a correlation between gait speed, power of the affected limb [8, 42, 50, 51] and quality of gait [43, 50, 59], so that a strong relationship to walking ability and independence of stroke patients is obvious.

Another study investigated a relationship between results of 6MWT and comfortable gait speed which showed a correlation with the degree of impairment. [16]. Due to this fact these test results are good indicators for independence of stroke patients.

The study population of our study did not reach any of the above listed distances, but especially here there were strong interactions between interventional and control group (6-MGT: p=0,003, 2-MGT: p=0,015). This argues for the MOTOmed movement therapy. Because both, 2 and 6MWT showed significant results, it becomes clear that at the retest, gait speed was higher for the whole period of 6 minutes than in the entry testing. Interestingly, there were no significant interactions concerning maximum gait speed (p=0,188). But one has to consider, that some of the patients were afraid of walking with their maximum speed due to the fear of falling. So we were not able to detect if there really was no potential to walk faster. On the other hand, this form of intervention aims at improvements of submaximal physical capacity. These aims were reached concerning the results in 2/6MWT and comfortable gait speed.

Steering of training, compliance of therapy

Compared to intensive therapeutic interventions during stationary abidance in a rehabilitation centre where patients are told to contribute to the rehabilitation outcome, motivation to do so plays a great role when these patients are released from inpatient rehabilitation. Thus, there is a relationship between the motivation to steer MOTOmed training "some hard", according to the BORG scale and the instructions, and the advancement as to motor capacity patients experience throughout this training. An often described fact is that many stroke patients stay inactive in periods of time with no therapeutic intervention. They rarely do some physical exercises to improve motor and physical capacity [2, 4, 19] and if they do so, they often need extrinsic motivation [61]. On the other side, the release from the stationary rehabilitation centre into home environment could enforce the patient to practice some exercise because now his restricted functional abilities become clear [11, 57]. Nevertheless, many stroke patients are released from inpatient rehabilitation without a possibility of maintaining or extending physical fitness [29].

The movement system used in this study offers an easy facility to arrange non-therapeutic time in a useful way and participate in the therapy result. High therapy compliance, as seen in the high frequency of training (mean 204 ± 55,9 sessions during the intervention period per patient) as well as the fact that patients trained for five more minutes (on average) than they were told to attest to a high acceptance of the MOTOmed system (Tab. 3 and 4). We assume that another reason for the numerous use of the system was the safety during exercising. Patients were able to work out in a sitting position. PEURALA et al (2004) described this is a fact, too [46].

In this investigation, we payed very much attention on the practical use of the MOTOmed system. Due to the fact that normally MOTOmed users are given a brief instruction into the handling of the apparatus and after this have to train on their own initiative, in the present study we did neither endurance testing nor offer a heart frequency-oriented training. Intensity of exercise was only steered by the BORG scale and entry intensity was fixed by a sports scientist according to stage 13 of the BORG scale ("a little strenuous") The given instructions were controlled by phoning the patients in intervals of 14 days. Though these instructions were very unspecific, patients showed motivation and compliance so that in week 16 a higher mean workload of 6,03 watts could be registered (week 1: 16, 56W±6,4W, week 16: 22,59W ± 11,16W, p=0,009). As shown by correlations coefficient, patients' entrance workload was geared according to patients' motor abilities as measured through 6MWT (r=0,72).

But with regard to patients' motivation, we have to mention that the treating doctor has a high impact on patients' attitude towards physical activity. PAYNE et al. (2001) could show this factor in a stroke study concerning patients' participation on a fitness training programme. As to the question for the motivation of participating on such a programme, this study documented that 70% of the interviewed stroke patients answered "if the doctor told me" [44].

In our study, compliance was also displayed in patients' interest to continue training with the MOTOmed system. 11out of 16 patients consulted their treating doctor for a prescription of the apparatus.

Conclusion

The supply of ongoing therapy after outpatient rehabilitation, e.g. the possibility to participate in a rehabilitation-sports group is often restricted by structural and local circumstances. On the other hand, a strong reduced mobility of the patients as well as long distances and times of journey represent a limiting factor. A possibility to increase the frequency of therapeutic interventions is, besides one-on-one treatment as it is usually done in physio- and ergotherapeutic interventions, to offer facilities, which engage patients' own initiative and can be practiced without supervision. [11]. These thoughts lead us to the conclusion, that MOTOmed movement systems are to be viewed as an alternative and supplementation of conventional therapy. The placement of the system into home environment and little expenditure were reasons that can explain the amount of exercising sessions during the period of intervention. Because of an easy handling and fixation of the feet and the lower legs to the apparatus, the patient can do physical exercise training independent from other persons. The documentation of the training sessions, as it was done in this study with the help of chip cards gives all treating persons involved in the rehabilitation process (e.g. doctors and therapists) a possibility to control the patient's amount, frequency and intensity of training.

In this way, these persons are given an opportunity to motivate the patient in carrying on physical exercise. The present study showed a high impact of the MOTOmed system on the improvement of 2/6MWT results, as well as comfortable gait speed and timed "Up&Go"-test. Due to the fact that the rate of stroke survivors is very high [49, 60] and cardiac complications are one of the most common causes of death in stroke survivors [54, 55] the strong need for prevention of immobility is evident to avoid secondary diseases. At this point, the MOTOmed movement system offers a solution. All participants of the study received two physiotherapeutic and two ergotherapeutic therapy sessions per week on average. Every session takes approximately half an hour. Especially for the physiotherapeutic sessions that work with Bobath's concept, the basic idea of these interventions is to inhibit nonphysiologic movements and spasticity [7]. No question, these forms of therapy can only be done in an one-on-one treatment. They concentrate on the use of neuroplasticity to treat primary neurological impairments. Besides this compensation of neurological problems, the MOTOmed movement system aims at the prevention of immobility-related secondary diseases. Patients ability to daily and independently exercise ("task-related" training) with this apparatus reduces the risk of cardiovascular and musculoskeletal complications on the one hand, and on the other it improves walking ability. Both, MOTOmed system and physiotherapeutic intervention, should make it possible to reach an optimal therapy result. The intensity of rehabilitation after stroke significantly contributes to a positive outcome, which again is pointed out in our and also in other studies [33, 46]. In contrast to other investigations [31], the improvement of patients test results (for example a longer distance walked in 6 minutes after having trained with the MOTOmed system) shows that even after six months post-stroke it is possible to expand patients capacity of mobility when offering adequate and motivating physical activity tasks.

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