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"Video Therapy": Promoting Hand Function after Stroke by Action Observation Training – a Pilot Randomized Controlled Trial

Christian Dettmers[1-3*], Violetta Nedelko[3,4], Thomas Hassa[3,4], Klaus Starrost[5] and Mircea Ariel Schoenfeld[3,6,7]

[1]Kliniken Schmieder Konstanz, Konstanz, Germany

[2]Faculty of Psychology, University Konstanz, Konstanz, Germany
[3]Lurija Institute, Kliniken Schmieder Allensbach, Allensbach, Germany

[4]Kliniken Schmieder Allensbach, Allensbach, Germany

[5]Schön Klinik, München, Germany
[6]Department of Neurology, University Clinic Magdeburg, Magdeburg, Germany

[7]Leibniz Institut für Neurobiologie, Magdeburg, Germany

*Corresponding author: Prof. Dr. Christian Dettmers, Kliniken Schmieder Konstanz, Eichhornstr.68, 78464 Konstanz, Germany, Tel: 0049 7531 986 3536; Fax: 0049 7531 986 3155; E-mail: c.dettmers@kliniken-schmieder.de

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Abstract

Background: Action observation improves excitability of the primary motor cortex and the encoding of motor engrams as well as motor-learning.

Objective: The intention of our pilot-study was to evaluate the feasibility of a six weeks home-based action observation training (video therapy) in stroke patients.

Methods: 56 patients (age 58 ± 13; time since onset 40 ± 82 months; NIHSS 3.5 ± 1.8) with a hand paresis following stroke were recruited from two rehabilitation clinics. Before discharge from the clinic the intervention group received a DVD displaying ten object-related motor tasks of varying difficulty, each lasting five minutes. Patients were requested to imitate the motor tasks one hour daily for six weeks ("video group"). A control group performed the same tasks with written instructions without observation/imitation ("text group"). A second control group was discharged without specific homework ("usual care group").

Results: There was no dropout in the video group. Quality and speed of the Motor Activity Log (MAL) increased significantly in the video and text group. Nine Hole Peg test (NHPT) and Stroke Impact Scale (SIS) improved only in the video group. Questionnaires (MAL and SIS), obtained twelve months after training in fourteen and eleven participants of both active groups, indicated significant differences in favor of the video group.
Conclusions: Video training is easy to deliver and highly accepted by patients. Six weeks of home based training suggests improvement of hand function, activities of daily living and quality of life. Video-therapy appears to be promising, as an adjunct to conventional neurorehabilitation – especially with regards to non-supervised, home-based training.

Keywords: Action observation; Mirror neurons; Motor observation; Pilot study; Randomized controlled trial; Stroke; Video therapy

Introduction

Observation of action modulates primary motor cortex excitability [1-4]. It has been suggested that action observation supports motor memory formation and possibly the motor learning system [5]. Training-dependent memory encoding is enhanced in elderly individuals through action observation, which also improves on the learning processes. This is a relevant issue in the field of neurorehabilitation [6]. It has been suggested that action observation can be potentially interesting for rehabilitation of patients with hand paresis [7]. A pilot study applied this concept to stroke rehabilitation and investigated the effect of "video therapy" on hand function [8]. Sixteen stroke patients participated in the study. They all had a moderate, chronic motor deficit of the upper limb as a consequence of middle cerebral artery stroke. The intervention consisted of four weeks

daily training with observation and imitation of motor acts for one hour. The control group practiced the same motor tasks described on a screen, without observation. The intervention group - whose motor skills improved - turned out to be superior to the control group [8]. The combined study, which also applied functional MRI (fMRI), suggested BOLD signal changes in cortical areas, which are related to the mirror neuron systems.

One possible neural mechanism involved in imitation is the mirror neuron system (MNS). Mirror neurons have been described in primates through single cell recordings and are located in the inferior frontal gyrus (IFG) and inferior parietal lobe (IPL) [9]. Their existence in humans is still controversial [10,11]. Functional imaging data in humans reveal much broader activations during action observation, than single cell recordings in monkeys. As a result the term "extended mirror neuron system" was coined [12]. Because of its putative character the mirror neuron system was also referred to as the "putative mirror neuron system" [13]. The effect of action observation

on the motor system and the encouraging results of a previous study [8] prompted us to reinvestigate the effect of action observation and imitation ("video training") as a home based training for the recovery of stroke patients. The study was planned as a monocentric pilot study to test its feasibility as well as to estimate potential treatment effects, in preparation for a larger forthcoming clinical study. The hypothesis was that home based video training for six weeks is possible, suitable and improves on impairment, participation and quality of life, more than the conventional discharge without specific homework (usual treatment).

Methods

Subjects

Fifty-six stroke patients were recruited from two hospitals (Kliniken Schmieder Konstanz and Allensbach) where they received post-stroke rehabilitation treatments between December 2007 and May 2010. All patients had presented a first-ever, clinically evident stroke causing a paresis of the upper limb (Table 1 for demographic details). Inclusion criteria were minimal function of the hand (ability to grip a small object and to release it (extension against gravity at wrist = 20° and at metacarpophalangeal and interphalangeal joints of each of the fingers = 10°)). Further inclusion criteria were sufficient language abilities to complete the study's questionnaires, and sufficient cognitive ability to understand and follow instructions for training. The distance to the patient's home was restricted to 300 km to allow for a follow-up examination. Exclusion criteria were as follows: prominent cognitive deficits (Mini-Mental-State <24), major depression (Beck Depression Inventory, BDI, >5), major aphasia (Token Test), apraxia (Florida Apraxia Screening Test, FAST), neglect (Albert's Neglect Test), hemianopia, prior infarct, leucencephalopathy and age below 18 or over 75 years, severe psychiatric disease, severe pulmonary or cardiovascular disease, epilepsy, severe joint deformity (neurological examination) and severe pain. Clinical data are provided in Tables 1 and 2.

		Group			
		Video	Text	Usual care	Total
	Total number	19	19	18	56
Age	Mean	62.79	53.89	58.83	58.50
	SD		14.74	11.25	12.93
Sex	F	8	5	5	18
	M	11	14	13	38
Handedness	L	4	0	3	7
	R	15	19	15	49
Side of infarct	L	11	10	12	33
	R	8	9	6	23
Dominant hand affected	NO	10	9	7	26
	Yes	9	10	11	30

Time since stroke onset [months]	Mean	37.91	55.37	26.74	40.25
	SD	69.96	106.93	61.69	81.61
Severity of palsy [1:mild – 3:high-grade]	Mean	1.68	1.89	1.67	1.75
	SD	0.75	0.74	0.77	0.74
NIHSS [1-4:minor stroke – 21-42:severe stroke]	Mean	3.42	4.15	2.93	3.51
	SD	1.87	2.00	1.28	1.79

Table 1: Summary of demographical and clinical data of all subjects. SD for standarddeviation, F female, M male

	Video	Text	Usual care group	Total
Embolic	6	9	7	22
Lacunar	4	4	5	13
Hemodynamic	2	1	2	5
Unknown Etiology	7	5	4	16
Cortical	5	6	5	16
Subcortical	14	13	13	40
MCA	17	16	16	49
Brainstem	2	3	2	7

Table 2: Type of stroke. MCA for middle cerebral artery

Participants were acquainted with the study's procedures, and written informed consent was obtained. For ethical reasons, participants of the usual care group were offered a DVD with motor tasks after finishing the six weeks protocol. The local ethical committee of the University of Konstanz approved the study. The study was registered at the German Centre for clinical studies at the University Freiburg (Clinical Trial Registration-URL: http://apps.who.int/trialsearch/. Unique identifier: DRKS00003825).

Intervention: Patients were randomly assigned to one of the three groups ("video", "text" and "usual care") for the home based training. A set of forty five video clips was produced, displaying object related movements of the hand or arm during typical activities of daily living (like grasping and lifting a glass, turning cards, picking up coins from the table etc.). Motor tasks had varying difficulties in order to fit different degrees of paresis. A set of 10-12 video clips (each lasting about 5 mins) individually chosen for the patient's deficit by the occupational therapist was distributed to the patients in the video group. Great care was taken by the occupational therapists to select motor tasks suitable to patients' impairment. Patients were asked to watch carefully each video sequence that was followed by the instruction: "Start to practice now!" The clip was then repeated for another four minutes in which the patient performed the displayed movement with the affected hand.

The participants of the "text group" practiced the same tasks as recorded in the video clips but instead of a video clip written instructions were shown on the screen. Text instructions were displayed on three consecutive screens: "Preparation" indicated the

position required for the task (i.e. sitting at the table) and the object needed to perform the task (i.e. glass or tennis ball). The second screen briefly described the task: what it entailed and what was expected to be done. The third screen stated: "Start to practice now!" Video- and text group practiced their individual set of tasks during the last therapy session before discharge from the rehabilitation clinic, to ensure correct understanding and task execution. In both groups the patients were instructed to train one hour per day for six weeks. A third group, the 'usual care'-group, did not receive any specific "home work" or training. All patients were allowed to get additional conventional therapies like physio- or occupational therapy. All patients were requested to keep a diary to record their training and additional therapeutic interventions that occurred within the training period.

Outcome Parameters: The following data were assessed as outcome parameters: Nine Hole Peg Test (NHPT) [14,15] and Wolf Motor Function Test (WMFT) [16] were used as objective laboratory motor tests. Questionnaires (Motor Activity Log (MAL) [17] were used to assess activities of daily living and quality of life (Stroke Impact Scale) (SIS) [18,19]. The motor test and the questionnaires were taken before (PRE) and after (POST) the intervention. Questionnaires (MAL and SIS) were sent out by mail one year after intervention to the participants of the video and text group. The NHPT was performed by measuring the time to place nine pegs into a board with nine holes with each hand. If patients failed to place the pegs, a maximal score of 300 seconds was recorded. A sum score was calculated for each hand (averaged over two trials). The WMFT assessed fourteen tasks, which were recorded on video. Video recordings allowed for evaluation by an experienced physiotherapist blinded to the allocation of the patients. Pairs (PRE and POST) of the video recordings of the WMFT were mixed in random order, to ensure that the physiotherapist evaluating the videos did not know which one was recorded prior and which was recorded after the training. Time for the execution of all tasks (WMFT-Time) was measured and the quality of performance (WMFT-Quality) was rated by the physiotherapist blinded to the randomization of the patients into the training groups. The MAL is a questionnaire in which patients rate 30 activities of daily living with regard to the quality of movement (MAL-QoM) and amount of use (MAL-AoU). SIS is a disease specific questionnaire which determines deficits on the motor, cognitive, emotional and social domain.

A follow-up investigation was scheduled twelve months after the training. Questionnaires (MAL and WMFT) were mailed to the video and text group. Patients from the usual care group could not be included in the follow-up analysis, because some of them for ethical reasons received a DVD with video clips on the day of the re-evaluation from us.

Protocol: Outcome parameters were assessed three days before discharge. A date for re-evaluation and visiting the clinic was scheduled in six weeks time after discharge. Since more than halve of the participants of the usual care group received a DVD after re-evaluation, the follow-up investigation after one year was restricted to the video and text group.

Statistics

The behavioral data was analyzed in two different steps. First, separate univariate ANOVAs with the factor GROUP were performed for the variables age, NHISS, NHPT. Non-parametric tests were performed for the variables which did not meet the requirements for an ANOVA. The multivariate analysis, which served to evaluate therapy effects, was conducted with dependent variables "WMFT-quality", "MAL-QoM", "MAL-AoU", and "SIS", factor TIME POINT with and factor GROUP.

Results

Fifty six stroke patients (18 females) were included and randomized to one of the three trial arms. Mean age of all participants was 58.5 ± 12.9 years. There were seven left-handers. Thirty three strokes were left-hemispheric, 23 right-hemispheric. The dominant hand was affected in 30 patients, the non-dominant in 26 patients. Mean time since the onset of stroke was 40.3 months. Time interval since stroke onset was <180 days in 30 patients, <90 days in 17 patients, <60 days in 6 patients and <30 days in no patient. According to an arbitrary distinction between mild, moderate and severe hand paresis 25 patients had a mild paresis, 21 a moderate and ten a severe paresis. NIHSS (3.5 ± 1.8) also indicates that most of the patients had a mild hemiparesis which was most prominent or exclusive to the arm (compare Table 1). Twenty two strokes were of embolic origin, 13 were categorized as lacunar strokes, 5 were of hemodynamic origin and 16 of unknown etiology. Sixteen infarcts had a cortical localization, 40 were subcortical infarcts. There were 49 middle cerebral artery (MCA) strokes and seven brainstem infarcts (compare Table 2).

Adherence/drop-out rates: One patient was excluded during the intervention because of occurrence of a recurrent stroke. One patient from the text-group called us to say, that she was not willing to continue the training and that she was unwilling to come to the re-evaluation. Another two patients refused to come to the clinic for re-evaluation. There was no drop out in the video group. There were no side effects reported in either group. Patients did not need any encouragement to complete the video training successfully. The amount of additional occupational and physiotherapies outside the protocol was not significantly different in the three groups (78 ± 64, 85 ± 45 and 103 ± 64 minutes / week in the video, text and usual care group).

There were not any significant differences between video-, text- and 'usual care'-group for the variables measured at the beginning (PRE) of the study, neither in the multivariate analysis with normal distributed variables (age, NIH-SS, NHPT), nor in the non-parametric tests with the variables which didn't meet the requirements for an ANOVA (gender, days after stroke, infarcted side, handedness, pareses of the dominant hand, pareses severity, and additional therapies). So the groups were comparable regarding demographical and clinical data. The data of all variables measured in PRE are summarized in Table. 1.

The multivariate analysis, which served to evaluate the therapy effects, with dependent variables, WMFT-Quality', ,MAL-QoM', ,MAL-AoU' and ,SIS', factor TIME POINT with two levels PRE and POST and factor GROUP (VIDEO, TEXT and 'USUAL CARE') revealed significant main effects for the group ($F_{(8,208)} = 3.161$, $p < 0.002$) and for the time point ($F_{(4,103)} = 2.686$, $p < 0.035$). Subsequent analyses revealed that the effect of group was due to the differences between text- and ,usual care'-group at the WMFT-Quality scale in PRE ($F_{(1,35)}=4.215$, $p<0.048$) and POST ($F_{(1,35)}=5.004$, $p<0.032$) and at the MAL-QoM ($F_{(1,35)}=4.728$, $p<0.037$) and MAL-AoU ($F_{(1,35)}=10.715$, $p<0.002$) in PRE. A significant main effect of group was also observed between text- and video-group at the MAL-QoM in POST ($F_{(1,36)}=4.648$, $p<0.038$). Thereby the patients of the text group had on all scales lower scores compared to the other two groups and

performed worse than other study participants. The effect of time point was due to significant improvements of all three groups (video: $F(1,18)=11.224$, $p<0.004$; text: $F(1,18)=10.034$, $p<0.005$; ,usual care': $F(1,17)=11.124$, $p<0.004$) on the WMFT-Quality scale. The video- and the text-group significantly ameliorated in MAL-QoM (video: $F(1,18)=17.693$, $p<0.001$; text: $F(1,18)=10.378$, $p<0.005$) and MAL-AoU (video: $F(1,18)=19.865$, $p<0.000$; text: $F(1,18)=19.457$, $p<0.000$) and the video-group became better in the SIS ($F(1,18)=4.667$, $p<0.044$).

The Wilcoxon-Rank-Sum-Test with entire sample of 56 subjects showed significant changes between both time points (PRE and POST) in WMFT-Time ($z=-4.356$, $p<0.0001$). Significant changes were also found in NHPT performed with the paretic hand ($z=-2.519$, $p<0.012$), but not in NHPT with non-paretic hand. Subsequent analyses of these data revealed significant improvements of all three groups (video: $z=-2.415$, $p<0.032$; text: $z=-2.656$, $p<0.008$; ,usual care': $z=-2.33$, $p<0.02$) on the WMFT-Time scale and in the video group ($z=-2.813$, $p<0.005$) regarding the NHPT with the paretic hand. Group mean values of the outcome parameters are illustrated in the following diagrams (Figure 1).

Follow-up investigation: After a six month period, fourteen of eighteen patients from the video group and eleven out of eighteen from the text group completed the questionnaires. Quality of movement (MAL-QoM) and amount of movement (MAL-AoU) remained stable after six months in both groups. SIS improved further, in the video group, but not in the text group. Unfortunately we were not able to include the Usual Care Group in this follow up questionnaire, since for ethical reasons, most of them received a DVD after the second investigation.

Discussion

Six weeks of home based training – based on repetitive action observation/perception/ imitation or alternatively on repetitive task oriented training – did not cause any side effects. Videotherapy was highly accepted by the patients. There were no drop outs from the videogroup and there were no reinforcement or phone calls necessary for keeping the patients in the trial. Results suggest that training – for one hour a day over a period of six weeks - caused an improvement of hand function according to self ratings by the patients (MAL-QoM and AoU). A laboratory motor function test (NHPT) indicated an improvement in hand function in the video group, which was absent in the text group. SIS suggests also an improvement in stroke related quality of life induced through video training. Twelve months follow-up investigation potentially proposes superiority of the video group compared to the text group related to Activities of Daily Living (MAL) and health related quality of life (SIS). This observation, however, cannot properly be derived from statistics, due to incomplete and small sample size. The study does not allow any inferences concerning the mechanisms of the therapy. The high acceptance by the patients, easy administration and delivery, the low costs, wide availability and potential benefit were encouragement to initiate and plan a larger multicenter randomized controlled trail [20].
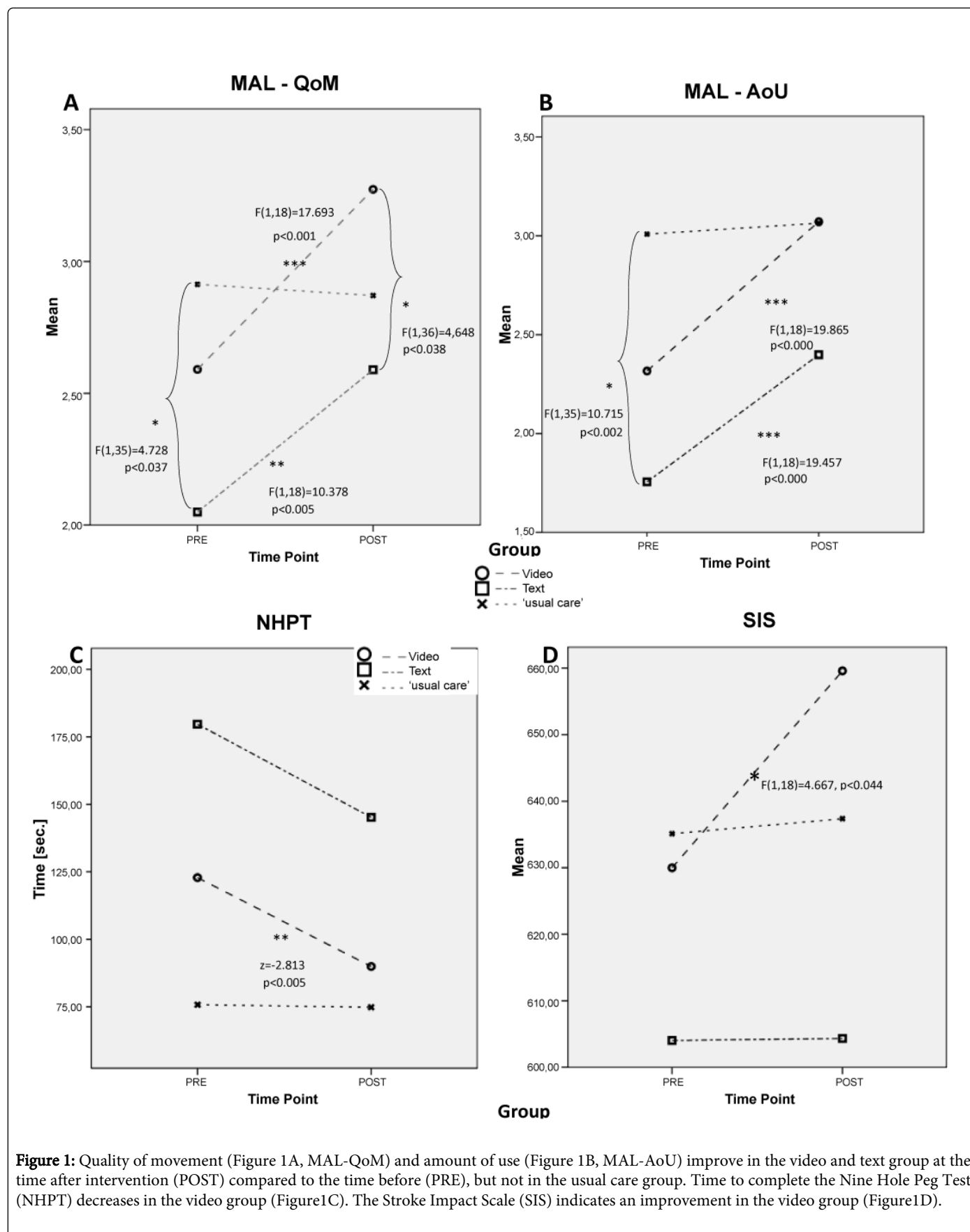
Video and text group improved both on the amount of use (MAL-AoU) and quality of movement (MAL-QoM). Improvements in the video- and active control group are in line with the concept that active training is the driving force of reorganization and plasticity [21-23]. NHPT and SIS advanced only in the video group. The increase in SIS argues for a clinically relevant progress. The follow-up investigation supports the idea that the induced changes are maintained and long lasting in the video group only, possibly even further increasing. Longitudinal recovery studies in stroke patients try to conceptualize a threshold of improvement, which a patient has to pass, to improve further on completion of training [24].

Although the idea is tempting - that the mirror neuron system is responsible or at least involved in the observed effect of this therapy - the present data do not facilitate making any inferences about potential mechanisms. Repetitive practising or task oriented training may explain a major part of its effectiveness. The intensity of the treatment is probably relevant. The participants were not blinded for the treatment and the knowledge of the patients to receive a novel therapy under investigation might cause a bias. Motivation may be superior in the video group. So we restrain from speculation to which degree action observation, action perception, action imitation, motivation, other psychological processes or all might contribute to the effectiveness of the video therapy.

The present data repeat results of a previous study that video therapy appears to be more effective than practising only without the additional effect of action observation/perception/imitation [8]. It is an extension of this study in the sense that the number of included patients is larger and a second control group is included. Also based on an incomplete sample size – we have indications that the effect is long lasting.

A relative large randomized controlled trial compared additional observation/imitation to conventional shoulder/arm practice in 102 acute stroke patients [25]. A Time x Treatment interaction emerged from the generalized estimating equations analysis of Box and Block Test, showing significant T0-T1 and T0-T2 differences in favor of the experimental group. A small randomized controlled pilot study encompassing thirty chronic stroke patients and three treatment arms compared action imagery and action observation in a control group [26]. Additional training induced additional improvement, but no differential effect between action imagery and action observation.

Functional imaging and neurosciences have inspired the field of rehabilitation. Many new techniques are based on new insights and neurophysiological concepts [22,27,28]. Translation into clinical practice is often slow and less successful. An explanation of the insufficient translation in practise may be explained by the fact that many studies demonstrated effectiveness of new therapies, but not superiority compared to conventional therapies. This supports the trend that therapists hesitate to substitute or replace conventional therapies through new developments. An obvious advantage of the current version of videotherapy lies in the fact that it is not meant to replace conventional therapy, but to complement and enhance existing techniques.

Figure 1: Quality of movement (Figure 1A, MAL-QoM) and amount of use (Figure 1B, MAL-AoU) improve in the video and text group at the time after intervention (POST) compared to the time before (PRE), but not in the usual care group. Time to complete the Nine Hole Peg Test (NHPT) decreases in the video group (Figure1C). The Stroke Impact Scale (SIS) indicates an improvement in the video group (Figure1D).

Very different aspects might support the value of videotherapy in the field of neurorehabilitation. To date, it is commonly acknowledged that the ultimate value of a rehabilitation technique is not determined at the end of the rehabilitation treatment before discharge, but rather six or twelve months later. Patient`s capacities and daily activities might develop very differently after discharge from the hospital. Some patients might further improve, some patients may not change their skills and some deteriorate [24]. Videotherapy might favour improvement at home after discharge from the hospital. Further aspects are motivation and engagement. It is increasingly recognized that motor learning, learning in general and particularly retention of skills, is intimately related to motivation. Motivation appeared to be high in our intervention group. In an ideal setting outside a standardized protocol, patients would get new videos every four weeks depending on their level of improvement and skilfulness to address the important aspect of shaping.

Action observation therapy is often classified as mental training. Remarkably, there are much more pilot studies [29], small randomized controlled studies [30] and reviews advocating motor imagery than studies in favour of motor observation [31,32]. A large trial surprisingly could not confirm the effectiveness of motor imagery – at least when it is performed in isolation and not in combination with practicing [33]. Another multicenter trial compared additional action observation to conventional therapy based on the neurodevelopmental technique. The experimental intervention was conducted three times a day over a six-week period [34]. Both groups improved; but there was no group effect. There are some indications, that motor imagery training requires experience [35], that it is only possible to relearn skills, which have been known before [36], that capacity to imagine might be initially [37] or partially [38] be impaired in stroke patients, particularly when the sensory system is impaired [39]. Future studies might indicate which therapy is more suitable in a particular patient. Our personal impression is that video therapy is easy to implement in a clinical setting and even suitable as home based therapy which does not require any supervision.

Our study has certain limitations. A major drawback is the incompleteness of follow-up questionnaires which excludes sophisticated statistics. Randomization failed to ensure that there are no differences in outcome parameter at the beginning of the investigation. The multivariate analysis demonstrated differences between the three groups at the baseline, which restricts the comparison of the effect sizes between the groups. Patients were recruited on clinical grounds (hand paresis in need for further treatment), not on MRI findings. We did not select patients with a particular stroke location (i.e. subcortical middle cerebral artery strokes). This increased the variability, but ensured that results may be generalized to the stroke population. WMFT turned out to be not sensitive enough to discriminate between group effects. Selected tasks in the video and text group were not identical in all patients, but depended on individual impairment. This might have introduced some variability and confounds, but it had the advantage of a high adherence and motivation of the patients. Higher prevalence rates of patients with light and moderate paresis than with severe paresis restricts the study`s generalization to this patient group.

Conclusions/Implications

Traditional physiotherapeutic concepts are complimented by new techniques and approaches based on physiological studies to derive the most effective and individually tailored therapy. Neurosciences have inspired clinicians to implement action observation in stroke rehabilitation. Because of the limited number of participants and suboptimal randomization procedure, we cannot draw firm conclusions regarding the effectiveness of the experimental intervention. Video training, however, is easy to deliver and highly accepted by patients. Six weeks home-based training demonstrated encouraging results concerning acceptance and adherence and promises further results concerning improvement of hand function, activities of daily living and quality of life. Because of its cost-effectiveness, it is recommended as an add-on home-based therapy to improve long term outcome after stroke. The present data supported the development of a protocol for a multicenter trial [20].

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