REHABILITATION MANUAL 8

# MANUAL FUNCTION TEST (MFT) AND FUNCTIONAL OCCUPATIONAL THERAPY FOR STROKE PATIENTS

Editors
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NATIONAL REHABILITATION CENTER
FOR THE DISABLED
JAPAN

(WHO COLLABORATING CENTRE)

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National Rehabilitation Center for the Disabled
WHO Collaborating Centre for Disability Prevention & Rehabilitation

Rehabilitation Manual 8

**Manual Function Test (MFT) and Functional Occupational Therapy for Stroke Patients**

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# PREFACE

The manual 'Manual Function Test (MFT) and Functional Occupational Therapy for Stroke Patients' is one belonging to the trilogy of stroke rehabilitation for post-acute phase.

In spring 1981, we started research works on the prediction of functional status of stroke patients at set times after starting medical rehabilitation. The detail of works, rehabilitation manual 6, 'Recovery Evaluating System (RES) for Stroke Rehabilitation', was published in March, 1999. After starting the research works, we noticed that several measures for impaired motor function of paretic upper extremity were not appropriate to our developmental approach of stroke rehabilitation. We were under pressure from other staffs of rehabilitation team to develop a scale assessing motor function of paretic upper extremity based on developmental analysis. After gathering clinical data of follow-up study, we made up Manual Function Test (MFT) in 1987, and began to use as the measure in the RES. MFT has been used in several rehabilitation hospitals for more than 10 years with confidence of occupational therapists. Using MFT, we can predict functional status of the affected upper extremity at set times and select optimal activities for the patient during post-acute phase of stroke.

We hope that physicians, occupational therapists and other rehabilitation staffs working for stroke patients will utilize this manual as a convenient clinical tool.

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**List of abbreviations**

CC : Carry a cube
FE : Forward elevation of the upper extremity
GR : Grasp
LE : Lateral elevation of the upper extremity
MFS : Manual function score
MFT : Manual function test
MFT-S : Manual function test score
PD : Touch the dorsum with the palm
PI : Pinch
PO : Touch the occiput with the palm
PP : Peg-board
RES : Recovery evaluating system for stroke rehabilitation
TSO : Time since stroke onset

# INTRODUCTION

One of the aims in medical rehabilitation is to improve the functional status of patients through therapeutic interventions. In order to assess the effectiveness of various types of intervention and therapy, it is necessary to know what the natural course of the disease and its consequences are likely to be (Langton-Hewer 1987). Assuming that there are significant correlations between clinical symptoms and signs and pathological changes of the affected organs and/or tissues, the natural course of the disease is often described by the changes of clinical manifestations occurring over a period of time in the traditional medical model. This strategy could be applied to the research on the natural course of patients' physical disabilities and/or functional status in medical rehabilitation. Therefore, it is important to make valid and reliable scales for functional assessment, which will be utilized to describe the natural course of physical disabilities and/or functional status.

According to Partridge et al. (1987), recovery from physical disability after stroke follows a predictable pattern and it is possible to develop profiles with which an individual's progress could be compared. Rehabilitative techniques for stroke patients such as the neurophysiological approach (Brunnstrom 1970) and the neurodevelopmental approach (Bobath 1966) are also based on the natural course of recovery, although the underlying assumptions of those approaches are not the same. Based on the natural course of functional recovery observed in stroke patients, the manual function test was developed to assess the impairments in motor function of the affected upper extremity (Moriyama 1987). According to reports of occupational therapists in several rehabilitation hospitals, the manual function test is simple and easy to use in clinical practice.

Moriyama et al. (1990 a), analyzing the data of 141 hemiparetic stroke patients followed up for more than 12 weeks, reported that the relationship between the time since stroke onset and the score of manual function test was well fit to the hyperbolic function in 84 patients (60%). In addition, most stroke patients showed a regular pattern of recovery of motor function of the affected upper extremity. Thereafter, Moriyama et al. (1990 b) developed a system of programmed learning based on the regularity of recovery patterns for the restoration of impaired motor function of the paretic upper extremity, and applied it to clinical practice since July, 1988. After slight modifications in the scoring method of the original manual function test in order to meet the requirement for interval measurement such as unidimensionality and additivity, manual function test-II was introduced into clinical practice (Moriyama et al. 1991).

In this manual, we describe the details of manual function test-II, which will be referred to as Manual Function Test (MFT), and occupational therapy program based on MFT-score (MFT-S) Recovery Profile.

# 1 MANUAL FUNCTION TEST (MFT)

## [1] The Axiom of MFT

MFT was developed in an attempt to assess the impairments in motor function of the affected upper extremity of stroke patients, and to statistically analyze the possible recovery processes during medical rehabilitation with following premises (Moriyama 1987) :

a) Functional and/or neurological recovery of motor function of the affected upper extremity progresses
   (a) from the proximal segment to the distal segment,
   (b) from mass movements to discrete or isolated movements, and
   (c) from moving to holding ;
b) Movements of the affected upper extremity progress
   (a) from short range to long range of motions, and
   (b) as for the direction of movements, from horizontal to diagonal and vertical ; and
c) Tasks progress from simple to complex tasks, i.e., from tasks performed with consecutive motions to those with combined, simultaneous, and compound motions*

## [2] Measurement Tool

MFT is composed of 32 test items, which examine arm motions and manipulative activities. Figure 1 presents specially designed measurement tool, which is now commercially available (MFT kit : SOT-5000, Sakai Iryo Co, Tokyo, Japan). Figure 2 shows eight tasks of MFT schematically. The patient is allowed to try each task three times before being scored as failure [0], since MFT is designed to measure the maximum performance rather than the average. Each test-item is scored as success [1], when the patient has passed over the criterion.

## [3] Specifications for Each Task

### 1) Arm motions

Kineto-sphere of the upper extremity is assessed using four types of arm movements. The patient

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* According to Karger et al. (1966), types of motion combinations are defined as follows :

(a) Consecutive motions : A consecutive motion combination occurs when the same or different body members sequentially perform a series of individual, complete motions involving no overlap or pauses between motions.

(b) Combined motions : A combined motion combination occurs when two or more motions are performed by the same body member during the time required by the limiting motion.

(c) Simultanous motions : A simultaneous motion combination occurs when a single, complete motion by one body member is performed and during the same time interval another body member performs a single, complete motion which consumes the same or less time.

(d) Compound motions : A compound motion combination occurs when, during the same time interval, one body member performs either a single or combined motion while another member executes a combined motion or more than one motion in a consecutive series.

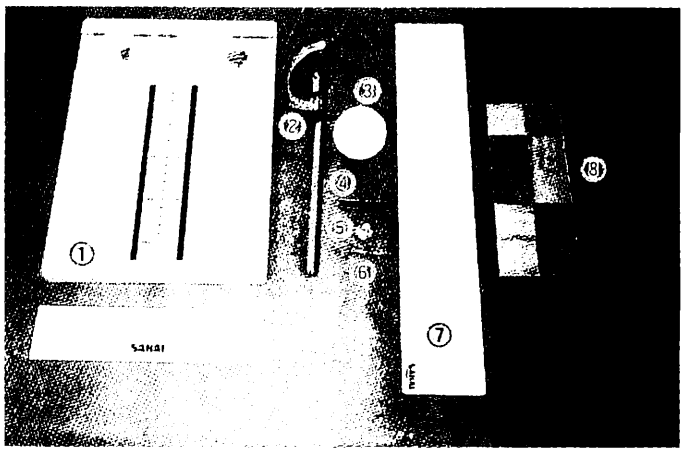


**Figure 1. Measurement tool of MFT.**

1. Peg-board (40 cm × 28 cm) with a longitudinally arranged 20 holes of 1.25 cm interhole distance. Length of each peg is 2.5 cm and its diameter 0.25 cm.
2. Goniometer.
3. Rubber-ball for base-ball game with 7 cm diameter and 130 g weight.
4. Pencil with 7 cm length and hexagonal shape.
5. Coin with 2.4 cm diameter and 0.12 cm thickness.
6. Needle with 5 cm length and 0.12 cm diameter.
7. Plastic board for task CC with 55 cm length, 10 cm width and 0.8 cm thickness.
8. Wooden 5 cm cubes for task CC.

(Nakamura et al. 1991)

sits on a stool and performs the movements, following the instruction of occupational therapist. Since each test-item belonging to the task is hierarchically structured, the occupational therapist may check only the maximum performance.

(1) Task FE : Forward elevation of the upper extremity

Instructions : Elevate your affected upper extremity forward as high as possible, while keeping the elbow in extended position.

Grading scale and cautions : Permit elbow flexion less than 60 degrees, and shoulder abduction less than 45 degrees.

FE-1——The shoulder flexion is less than 44 degrees.

FE-2——The shoulder flexion ranges from 45 to 89 degrees.

FE-3——The shoulder flexion ranges 90 to 134 degrees.

FE-4——The shoulder flexion is more than 135 degrees.

(2) Task LE : Lateral elevation of the upper extremity

Instructions : Elevate your affected upper extremity laterally with the elbow extended.

Grading scale and cautions : Permit elbow flexion of less than 60 degrees and shoulder flexion of less than 45 degrees.

LE-1——The shoulder abduction is less than 44 degrees.

LE-2——The shoulder abduction ranges from 45 to 89 degrees.

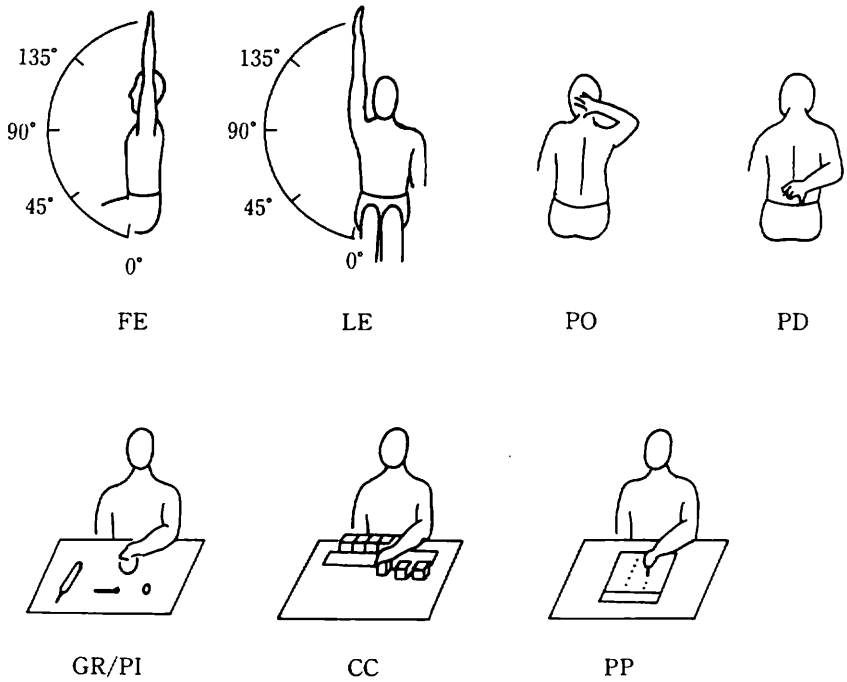



**Figure 2. Schemata of eight tasks of MFT.**

FE : forward elevation of the upper extremity, LE : lateral elevation of the upper extremity, PO : touch the occiput with the palm, PD : touch the dorsum with the palm, GR : grasp, PI : pinch, CC : carry a cube, PP : peg-board.

(Nakamura et al. 1992)

LE-3——The shoulder abduction ranges from 90 to 134 degrees.

LE-4——The shoulder abduction is more than 135 degrees.

(3) Task PO : Touch the occiput with the palm

Instructions : Touch your occiput with the palm of affected side.

Grading scale and cautions : For patients with decreased range of motion (ROM), ask the patient to touch his/her ear or mouth with the affected hand.

PO-1——Slight movements of the affected upper extremity is observed, indicating the patient's effort.

PO-2——The affected hand elevates above the xiphosternal plane.

PO-3——A part of the hand touches on the occiput/temple.

PO-4——The palm touches firmly on the occiput and MP joints reach up to the midline of the occiput.

(4) Task PD : Touch the dorsum with the palm

Instructions : Touch your back with the palm of affected side firmly.

Grading scale and cautions : Permit forward flexion of the trunk.

PD-1——Slight active movements of the shoulder are noticed, indicating the patient's effort.

PD-2——A part of the affected hand such as fingers touches on the ipsilateral buttock.

PD-3——The fingertips touch on the midline of the dorsum.

PD-4——The palm touches firmly on the dorsum and MP joints reach out beyond the midline.

**2) Manipulative activities**

A. Grasp and pinch

Grasp, carry and release-load function of the hand are assessed using a rubber-ball (used for baseball game). Also the ability to pinch and to pick up three objects, different in size and shape, with the thumb and fingers is assessed. The patient sits on chair in front of a table. The height of chair and/or table is adjusted to keep the elbow angle at 90 degrees with slightly flexed shoulders, when the patient puts his/her forearms on the table.

(1) Task GR : Grasp

Instructions : Grasp the ball and hold it up. Then, release and/or drop the ball.

Grading scale and cautions : The affected forearm is passively kept at the pronated position by the examiner (usually the occupational therapist) if necessary, with the elbow flexed at 90 degrees.

GR-1——The patient may be assisted in grasping the ball. He/she can keep holding the ball up, when the forearm is actively or passively lifted from the table.

GR-2——He/she can release the ball after holding it up and drop it on the table.

GR-3——He/she can grasp the ball on the table and hold it up without assistance, then drop the ball.

(2) Task PI : Pinch

Instructions : Pick up a pencil, a coin or a needle on the table.

Grading scale and cautions : The patient is permitted to perform a few trials before the actual testing.

PI-1——He/she can pick up a pencil.

PI-2——He/she can pick up a coin.

PI-3——He/she can pick up a needle.

B. Arm and hand activities

Integrated functions of the arm and hand, i. e., reach, grasp, carry and release, and finger dexterity, are assessed. The patient sits on a chair in front of a table. The examination should be performed after the patient is well accustomed to the task by verbal instruction, demonstration and a few trials. The number of completed trials within preset times should be counted.

(1) Task CC : Carry a cube

Instructions : The patient sits in front of the table on which are eight wooden cubes (5 cm) and a plastic board of 10 cm width. Ask the patient to grasp a cube on the side of the board with the affected hand in any fashion, carry it forward more than 10 cm, i. e., beyond the board, and release it on the table, and then repeat the same task as fast as possible.

Grading scale and cautions : The number of cubes transferred within 5 sec are counted.

CC-1——1 to 2 cubes.

CC-2——3 to 4 cubes.

CC-3——5 to 6 cubes.

CC-4——7 to 8 cubes.

(2) Task PP : Peg-board

Instructions : Ask the patient to transfer a peg from the saucer to the board and insert the peg into a hole of the board one by one from the top of line to the bottom as fast as possible.

Grading scale and cautions : The number of pegs correctly transferred within 30 sec are counted.

PP-1——1 to 3 pegs.

PP-2——4 to 6 pegs.

PP-3——7 to 9 pegs.

PP-4——10 to 12 pegs.

PP-5——13 to 15 pegs.

PP-6——16 pegs and over.

## [4] MFT Sheet and MFT-S Recovery Profile Chart

Table 1 shows the MFT sheet. When the examination is completed, the number of test-items being scored as success [1] are added up. The maximum of MFT-S is 32. MFT-S is multiplied by 3. 125 in order to make the maximum total score as 100, which is referred to as manual function score (MFS).

Figure 3 shows MFT-S Recovery Profile Chart, which is made using data from 120 stroke patients. On each figure, the abscissa indicates MFT-S and the ordinate denotes the standard value (Nakamura et al. 1991). The procedure to use the profile is as follows ;

( a ) After obtaining the MFT-S of the patient, the occupational therapist-in-charge records the performance score of each task on MFT-S Recovery Profile Chart ;

( b ) The occupational therapist checks the tasks scored below the standard value, which indicate a delay in motor recovery at the time of assessment ; and

( c ) The occupational therapist then selects optimal activities aimed at the facilitation of motor recovery related to those tasks, to be utilized in the succeeding training session.

## [5] Reliability and Validity of MFT

Recent studies on functional outcome measures of stroke rehabilitation have stressed the critical examination of the functional rating scale and the statistics used (Merbitz et al. 1989, Wright et al. 1989 ; Lyden et al. 1991 ; Silverstein et al. 1991, 1992 ; Vanclay 1991).

MFT was originally developed as an assessment tool of the affected upper extremity of hemiparetic stroke patients. MFS was significantly related to the stage of motor recovery (Brunnstrom 1970) and to task-performance of developmental milestones such as tasks of Motor Age Test (Johnson et al. 1951), indicating concurrent validity (Figure 4, Figure 5). Reliability of MFT examined by a test-retest method was high enough (the affected side : $r=0.99$ ; the non-affected side : $r=0.84$, $p<0.01$, respectively). Table 2 presents the reliability coefficients of the MFT tasks. Except Peg-board (PP), reliability coefficients are high.

Although the MFT was primarily made up of an ordinal scale, Guttman's scale analysis (Guttman 1950) performed on the data obtained from 120 patients, after slight modification of the scoring method, has shown the coefficient of reproducibility $=0.940$ and the coefficient scalability $=0.804$, indicating its scalability or unidimensionality (Moriyama et al. 1991). Accordingly, MFS could be treated as an interval scale (Hamilton et al. 1989 ; Johnston 1989) . A patient's MFS appears to reflect the level of impairment of motor function of the affected upper extremity, and the changes of MFS during medical rehabilitation will correspond with how much the patient has recovered (Nakamura et al. 1992).

**Table 1. Manual Function Test (MFT) Sheet**

When the examination is completed, the number of test-items being scored as success [1] are added up. MFT record of the right hemiparetic patient, 60 year old, male, is written as an example. MFT-S (MFS) is 12 (38).

| RES : | | Name : IS | | Date : July 16, '99 | (Examiner SM) |
|---|---|---|---|---|---|
| Subtest | | Item | Left | Right | Comment |
| Arm motions | FE | 0°～44° | | 1 | |
| | | 45°～89° | | 0 | |
| | | 90°～134° | | 0 | |
| | | 135°～ | | 0 | |
| | LE | 0°～44° | | 1 | |
| | | 45°～89° | | 1 | |
| | | 90°～134° | | 0 | |
| | | 135°～ | | 0 | |
| | PO | Move the arm slightly | | 1 | |
| | | Elevate the hand above the xiphosternal plane | | 1 | |
| | | Touch the head with fingers | | 1 | |
| | | Touch the occiput with the palm | | 0 | |
| | PD | Move the arm slightly | | 1 | |
| | | Touch the buttock with fingers | | 0 | |
| | | Touch the spine with fingers | | 0 | |
| | | Touch the spine with the palm | | 0 | |
| Manipulative activities | GR | Keep the ball in the palm | | 1 | |
| | | Release and drop the ball | | 1 | |
| | | Grasp and carry the ball | | 1 | |
| | PI | Pinch and pick up the pencil | | 1 | |
| | | Pinch and pick up the coin | | 0 | |
| | | Pinch and pick up the needle | | 0 | |
| | CC | One to 2 cubes within 5 sec | | 1 | |
| | | 3 to 4 | | 0 | |
| | | 5 to 6 | | 0 | |
| | | 7 to 8 | | 0 | |
| | PP | One to 3 pegs within 30 sec | | 0 | |
| | | 4 to 6 | | 0 | |
| | | 7 to 9 | | 0 | |
| | | 10 to 12 | | 0 | |
| | | 13 to 15 | | 0 | |
| | | More than 16 | | 0 | |
| MFT-S (32) | | | | 12 | success=1, failure=0 |
| MFS (100) | | | | 38 | |

(Nakamura et al. 1992, modified)

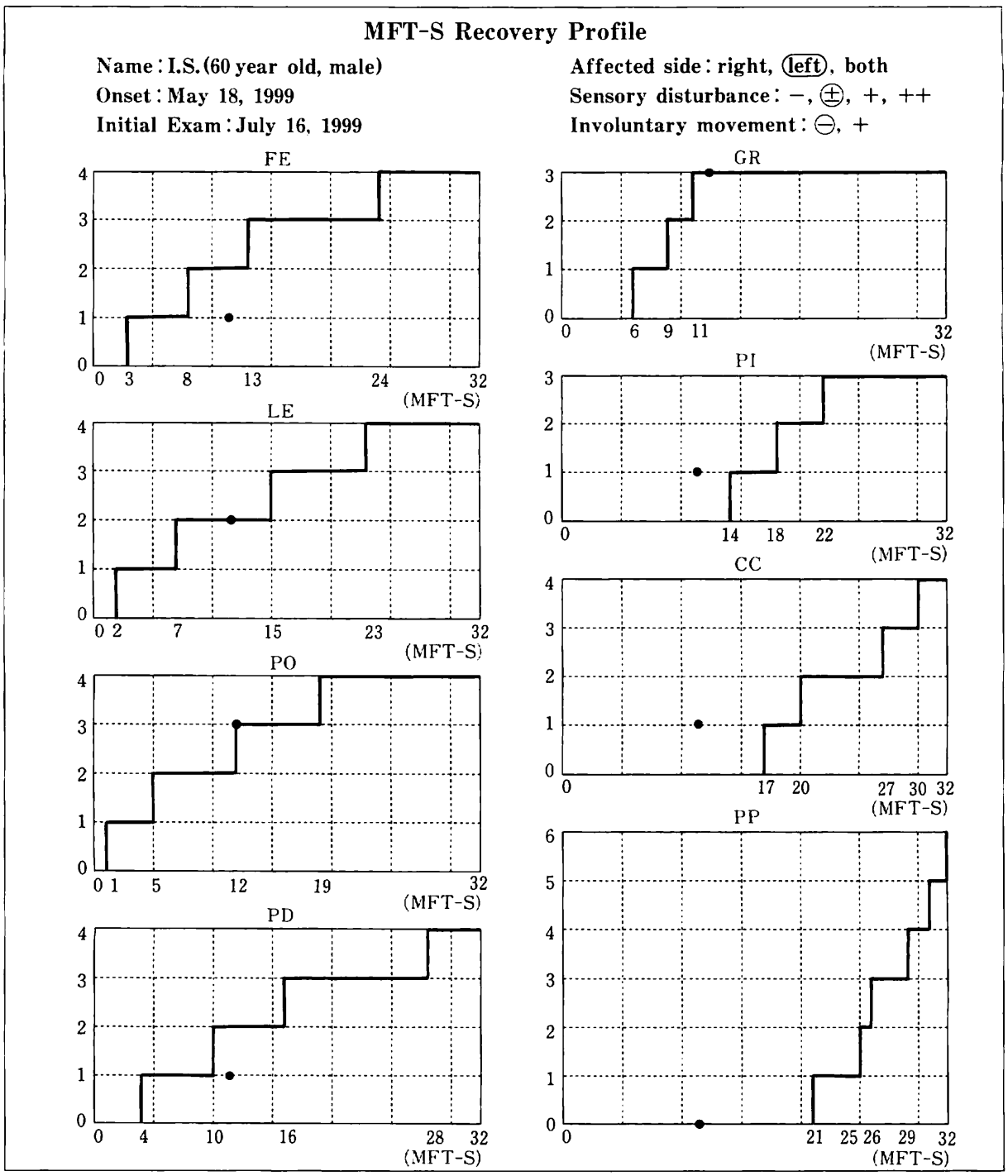



**Figure 3. MFT-S Recovery Profile Chart**

Relationship between MFT-S and score of eight tasks is superimposed on the line graphs of standard recovery profile. Scores of the patient presented in Table 1 are plotted on the chart. Clinical examinations demonstrated limited ROM of the upper extremity, moderate difficulty to keep the arm in static postures, inability to flex the shoulder with the extended elbow joint, and disturbed position sense of the upper extremity. Since the score of two tasks, FE and PD, are low as compared with the standard values, the principal aim of occupational therapy to be followed is to increase active ROM of the shoulder joint. Playing deck quoits with active-assistive movments, moving a quoit to the backward, and handicraft of lacing, i. e., holding a leather-sheath with the affected hand and sewing with the non-affected hand, are selected as activities. (Nakamura et al. 1997, modified)

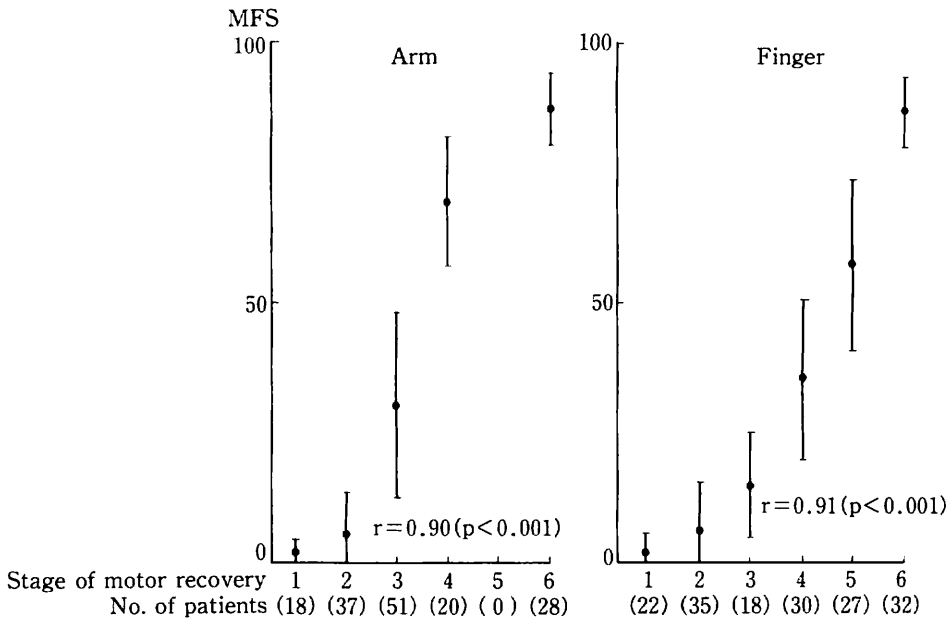



**Figure 4. Relationship of MFS to Brunnstrom's stage of motor recovery**
(Moriyama 1987)

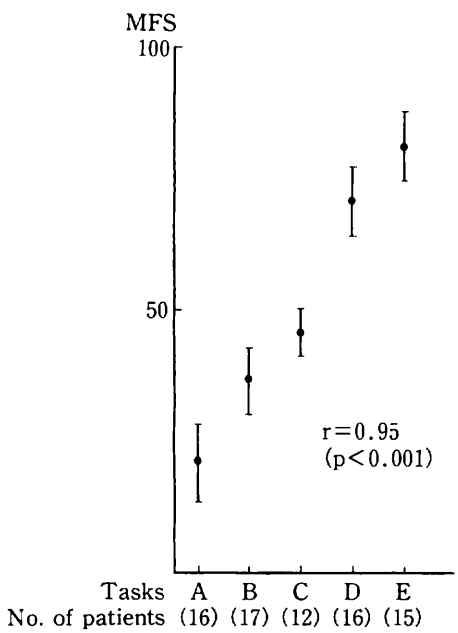



**Figure 5. Relationship of MFS to task-performance of developmental milestone**

A : grasp a ball (4 months equivalent)
B : put a block on a block (15 months)
C : draw a circle (30 months)
D : write a letter (60 months)
E : use chopsticks (60 months)

(Moriyama 1987)

**Table 2. Reliability coefficients of MFT items**

| | Intra-rater | Inter-rater |
|---|---|---|
| 1 FE | 1.000 | 0.429 |
| 2 LE | 0.938 | 0.474 |
| 3 PO | 0.855 | 1.000 |
| 4 PD | 0.878 | 0.500 |
| 5 GR | 0.870 | 0.861 |
| 6 PP | 0.376 | 0.500 |

(Cohen' index "Kappa")

(Nakamura et al. 1991)

# 2 ON THE PREDICTION OF FUNCTIONAL RECOVERY OF THE AFFECTED UPPER EXTREMITY

The ability to give an accurate prediction of functional outcome is extremely important and forms the basis of good medical rehabilitation practice.

Twitchell (1951), examining the sequence of motor recovery of the affected upper extremity of stroke patients, reported that the return of proprioceptive facilitation and a proximal traction response within 2 weeks were good prognostic signs for recovery of voluntary movements. Thereafter, most studies on motor recovery of hemiplegic patients have focused on the regularity of recovery patterns assessed by either kinematic changes or motor performance, classifying the patients' status into several stages or giving them some scores based on a specific criterion (Brunnstrom 1970, Moriyama 1987). In addition, previous studies have attempted to determine clinical or demographic variables as predictors of the level of motor function at a set time after stroke (Gresham 1986, Jongbloed 1986, Nakamura et al. 1990). Moreover, several studies have noted that the degree of paresis at the initial assessment is significantly related to functional outcome of the affected upper extremity (Bard et al. 1965, Wade et al. 1983, Olsen 1990, Duncan et al. 1994). Recently, Katrak et al. (1998) reported that the ability to shrug or abduct the shoulder early in the course of stroke was a good predictor of later hand movement and hand function, and even minimal finger movement noted at an average period of 11 days after stroke predicted good hand movement and function.

Jongbloed (1986), after critically reviewing studies on prediction of function after stroke, claimed that future studies on the prediction of function after stroke should measure function at set times post-stroke. Another important issue related to recovery of function is to quantify prediction of functional status with a standardized measure. The following study is on the line of those researches.

## [1] Data Base Model and Prediction of MFS at 4, 8 and 12 Weeks after Starting Occupational Therapy

The data base storing comprehensive information of patients is necessary both for functional assessment and recovery evaluation in stroke rehabilitation. Functional recovery or outcome, both assessed by measures of impairments and disabilities, can be predicted by applying an appropriate multivariate statistical analysis to the data base. Figure 6 shows a data base model following the International Classification of Impairments, Disabilities, and Handicaps (WHO 1980), on which our data base for stroke rehabilitation has been constructed (Nakamura et al. 1990, 1991). Functional status and its recovery are assumed to be related to neurological diagnosis, symptoms and signs. Functional status at admission may be characterized by use of various measures covering physical and psychological impairments and disabilities of the patient. The functional recovery process during inpatient rehabilitation at set times can be followed by using the same measures. Demographic characteristics of the patients may also affect their functional status and recovery. During the past 10 years, we have stored information of more than 1,000 stroke patients in the data base. Multiple regression equations to predict functional recovery were obtained from the data base and statistical analyses. The functional status of each patient at 4, 8 and 12 weeks after admission has

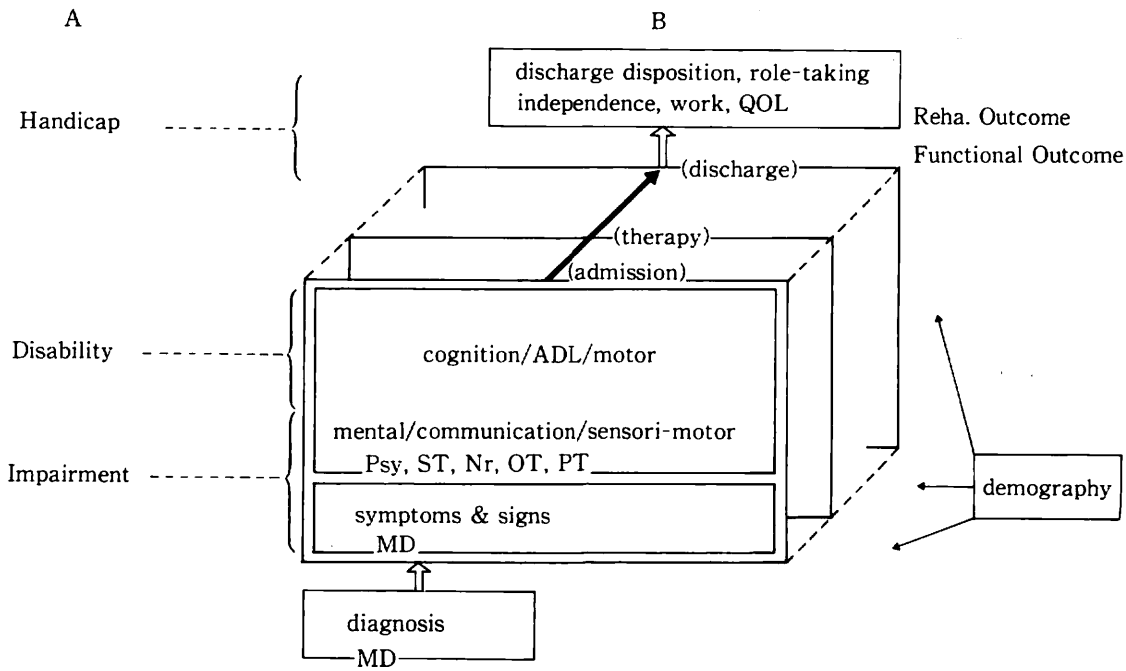



**Figure 6. ICIDH model (A) and data base model (B)**
(Nakamura et al. 1990)

been predicted at the start of his/her rehabilitative training by putting the data related to impairments, disabilities and demographic variables of the patient to those equations. In this way the Recovery Evaluating System (RES) for stroke rehabilitation has been developed in Institute of Rehabilitation Medicine and Narugo-Branch Hospital, Tohoku University School of Medicine, Miyagi, Japan. Details of RES is written in "Rehabilitation Manual 6. Recovery Evaluating System for Stroke Rehabilitation (Nakamura 1999)."

MFS at 4, 8 and 12 weeks after starting occupational therapy can be predicted on a group basis, using demographic variables, initial MFS and neurological impairments as independent variables (Table 3). Table 4 presents equations for the prediction of MFS at 4, 8 and 12 weeks after starting occupational therapy. Although the initial MFS is a moderate predictor of MFS for 4 and 8 weeks later ($R^2>0.82$, respectively), the prediction of MFS for a single patient with the equation obtained by the multivariate analysis has often failed with relatively high rate of error.

## [2] The Recovery Process of MFS Fits Hyperbolic Function in Most of Stroke Patients

Another way to quantify MFS at set times is the use of the equation obtained by the approximation of the relationship between the time since stroke onset (TSO) and MFS. The relationship of TSO (x) and MFS (y) could be presented in terms of a coefficient for the hyperbolic function, $y=A-B/x$. Initially, we recorded MFS once every 4 weeks after starting a conventional occupational therapy in 141 hemiparetic patients (Moriyama et al. 1990 a). A statistically significant approximation of the relationship between TSO and MFS to the hyperbolic function, as shown in Figure 7, was obtained in 84 patients (60%). Multivariate discriminant analysis of quantitative data (Hayashi's quantification I) indicated significant factors for the approximation as follows: (i) patient's

**Table 3. The variables used in RES-4**

| Variables | Abbreviations | Code |
|---|---|---|
| Motor Age Test | MOA | 0-72 |
| Manual Function Score (affected side) | AMFS | 0-100 |
| Barthel Index | BI | 0-100 |
| Hasegawa's Dementia Scale-Revised | HDS-R | 0-30 |
| Standard Language Test of Aphasia | SLTA | 0-100 (mean of five categories) |
| Age | AGE | (years) |
| Sex | SEX | Male=0, Female=1 |
| Time from onset to admission | TOA | * |
| Operation (brain-surgery) | OPE | 0, 1 |
| Coma (acute phase) | COMA | 0, 1 |
| Attack number | ATTACK | 1, 2, 3** |
| Diagnosis | | |
| Cerebral hemorrhage | ICH | 0, 1 |
| Cerebral infarct | CI | 0, 1 |
| Subarachnoid hemorrhage | SAH | 0, 1 |
| Hypoarousal state | HYPOAR | alert=0, others=1 |
| Visual field defect | VF | 0, 1 |
| Ocular movement disorder | OCULAR | 0, 1 |
| Nystagmus | NYSTAG | 0, 1 |
| Aphasia | APHASIA | 0, 1 |
| Spasticity | SPASTIC | 0, 1 |
| Exaggerated tendon reflex | DTR | 0, 1 |
| Pathological reflex | REFLEX | 0, 1 |
| Palsy | PALSY | 0, 1 |
| Sensory disturbance | SENSORY | 0, 1 |
| Ataxia | ATAXIA | 0, 1 |
| Involuntary movement | INVOL | 0, 1 |
| Bladder and bowel disturbance | RECTO | 0, 1 |
| Cognitive disorders | COGNT | 0, 1 |
| Diabetes mellitus | DM | 0, 1 |
| Hypertension | HT | 0, 1 |
| Heart disease | CD | 0, 1 |
| Joint contracture | CONTR | 0, 1 |

if not denoted, 0=absent and 1=present.

* 0-30 days TOA=0 : 31-60 days TOA=1 : 61-90 days TOA=2 : 91-180 days TOA=3 : 181-365 days TOA=4 : ≥ 366 days TOA=5

** patients with attacks more than three times belong to 3.

(Nakamura et al. 1997, Nakamura 1999)

initial MFS ranged from 26 to 75, (ii) the occupational therapy started within 4 weeks after stroke onset, (iii) lesions located within the hemisphere, and (iv) patient's WAIS-IQ was more than 60. We found a significant approximation in 24% of patients with an initial MFS more than 76 and in 53% of those with an initial MFS less than 25, suggesting that a ceiling or a floor effect of MFT contributed partly to these low percentage. However, using the data of MFT performed once a week for 7 weeks, a significant approximation was obtained every patient with MFS less than 25 (Moriyama et al. 1990 b). Figure 8 presents the MFS of patients with a significant approximation from the data of 4 weeks and those without at the start of occupational therapy, and 4, 8 and 12 weeks thereafter. The gain of MFS was larger in patients with significant approximation, compared to

**Table 4. Equations for the prediction of MFS at 4, 8 and 12 weeks after starting occupational therapy.**

At 4 weeks (one month)

MFS 1=21.072+0.986×MFS 0−0.119×AGE−2.06×TOA−2.171×COMA−2.231×COGNT−1.75×ICH−2.274×VF
(n=766, R=0.957, $R^2$=0.916)

At 8 weeks (2 months)

MFS 2=35.279+0.971×MFS 0−0.238×AGE−3.017×TOA−2.477×COMA−2.741×APHASIA−2.901×COGNT−2.993×ICH (n=676, R=0.928, $R^2$=0.86)

At 12 weeks (3 months)

MFS 3=45.154+0.981×MFS 0−0.327×AGE−3.616×TOA−2.77×COMA−3.24×APHASIA−4.173×COGNT−4.165×ICH (n=481, R=0.901, $R^2$=0.812)

(Nakamura et al. 1997, Nakamura 1999)

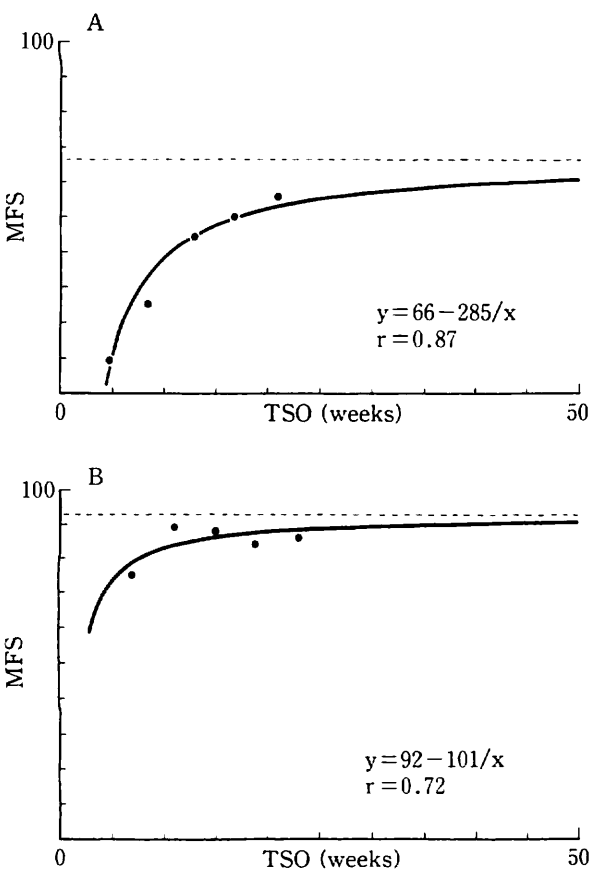



**Figure 7. Relationship between TSO and MFS approximated to hyperbolic function**

A : An example of significant approximation. A 56 year old female. Left hemiparesis due to right putaminal hemorrhage.

B : An example of non-significant approximation. A 52 year old male. Left hemiparesis due to subarachnoid hemorrhage.

(Nakamura et al. 1991)

patients without significant approximation.

## [3] Whose Recovery Is Most Predictable ?

We attempted to clarify the characteristics of patients with typical motor recovery of the affected upper extremity (Nakamura et al. 1992). From January 1989 to May 1991, 239 stroke patients were admitted to Narugo-Branch Hospital, Tohoku University School of Medicine. Their demographic variables, neurological impairments and results of functional measures at set times were stored in the data base, RES. Among them 174 patients (72.8%) were recruited as the subjects for the study based

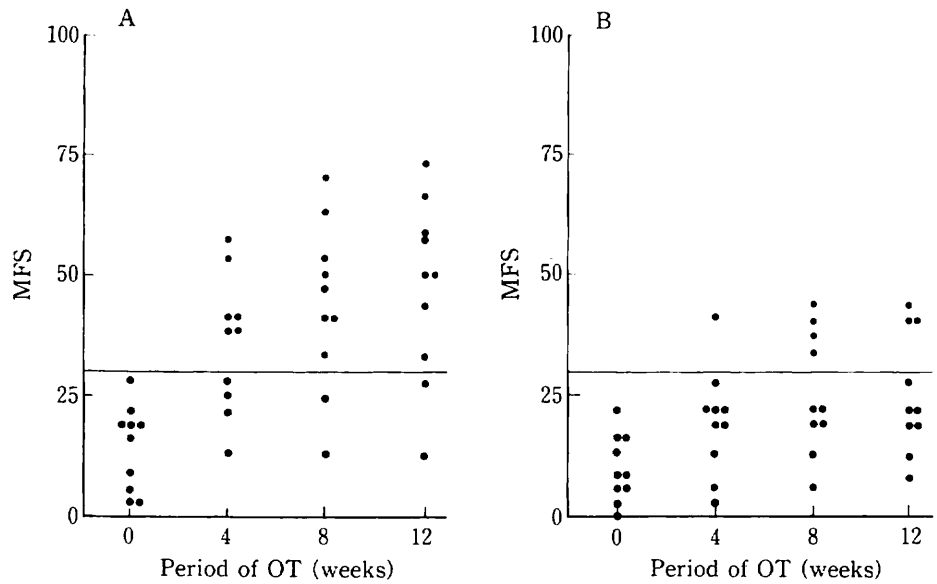



**Figure 8. MFS at the start, 4, 8 and 12 weeks after occupational therapy**
A : Patients with statistically significant approximation.
B : Patients without significant approximation. MFSs of both groups are below 30 at the start of occupational therapy. Functional gain is large in group A, compared to group B.

(Moriyama et al. 1990 c)

on the following criteria : ( i ) they could follow the instructions of the occupational therapist-in-charge, ( ii ) their training program based on MFT-S Recovery Profile continued for more than 8 weeks, and (iii) CT examination was performed before and/or at the admission. In general, MFT was performed once a week for more than 8 weeks. Applying the hyperbolic function, $y=A-B/x$, in which x is TSO (weeks) and y is MFS, to 6 to 9 data obtained from the 8-week performance record of each patient, values of parameter A and B were estimated by least square approximation. The patients were divided into two groups ; one group with a statistically significant approximation, and the other without. The former is referred to as 'the fit' group, and the latter as 'the non-fit.' Figure 7 shows the relationship between TSO and MFS of patients belonging to the fit and the non-fit groups.

During the 8-week follow-up, 6 to 10 data from each patient were stored in RES. A significant approximation was obtained in 125 patients (71.8%). Table 5 shows the demographic variables and neurological impairments of both groups. Compared to the non-fit group, the patients are younger and TSO is shorter in the fit group. The ratio of aphasic patients to non-aphasic patients is significantly higher in the non-fit group. Also the ratio between patients with urinary and/or bowel incontinence and those without is higher in the non-fit group. WAIS-IQ is definitely higher in the fit group. MFS at the start of occupational therapy and 8 weeks thereafter, and the functional gain are higher in the fit group than in the non-fit group (Table 6). Table 7 presents data of the CT findings. The ratio of patients with lesions in the frontal cortex to those without is significantly lower in the fit group than in the non-fit ($p<0.01$). In the fit group, the number of patients without cortical lesions, other than the frontal lobe, is significantly smaller compared to those with cortical lesions

**Table 5. Demographic variables and neurological impairments of the fit and the non-fit groups at the admission**

| | Fit (n=125) | Non-fit (n=49) |
|---|---|---|
| Age (years)[a] | 57.2±10.6 | 62.2±9.2[d,**] |
| Time since onset (weeks)[a] | 11.6±8.0 | 15.6±9.1[d,**] |
| School career (years)[a] | 9.6±2.4 | 8.8±2.2 |
| Sex (male : female) | 92 : 33 | 37 : 12 |
| Paretic side (left : right) | 63 : 62 | 20 : 29 |
| Diagnosis (CI : CH)[b] | 68 : 57 | 25 : 24 |
| Palsy (flaccid) (+ : −) | 16 : 109 | 11 : 38 |
| Palsy (spastic) (+ : −) | 99 : 26 | 37 : 12 |
| Sensory disturbance (+ : −) | 29 : 96 | 8 : 41 |
| Hemianopsia (+ : −) | 12 : 113 | 10 : 39 |
| Abnormal ocular movements (+ : −) | 4 : 121 | 1 : 48 |
| Nystagmus (+ : −) | 3 : 122 | 0 : 49 |
| Vertigo (+ : −) | 1 : 124 | 1 : 48 |
| Exaggerated tendon reflexes (+ : −) | 120 : 5 | 48 : 1 |
| Pathological reflexes (+ : −) | 111 : 14 | 45 : 4 |
| Dysphagia (+ : −) | 12 : 113 | 5 : 44 |
| Dysarthria (+ : −) | 47 : 78 | 23 : 26 |
| Aphasia (+ : −) | 28 : 97 | 21 : 28[e,**] |
| Ataxia (+ : −) | 1 : 124 | 4 : 45[e,*] |
| Involuntary movements (+ : −) | 11 : 114 | 4 : 45 |
| Urinary and bowel incontinence (+ : −) | 8 : 117 | 12 : 37[e,**] |
| Cognitive disorders (+ : −) | 50 : 75 | 18 : 31 |
| WAIS-VIQ (<60 : 60−79 : 79<)[c] | 22 : 37 : 66 | 21 : 16 : 12[e,**] |
| WAIS-PIQ (<60 : 60−79 : 79<)[c] | 25 : 48 : 52 | 26 : 17 : 6[e,**] |
| WAIS-FIQ (<60 : 60−79 : 79<)[c] | 31 : 39 : 55 | 28 : 13 : 8[e,**] |
| Grip-strength (affected side) (kg)[a] | 3.8±6.8 | 3.2±7.7 |

[a]Values are expressed as the mean±S. D.
[b]CI, cerebral infarct ; CH, cerebral hemorrhage.
[c]WAIS, Wechsler intelligence score ; V, verbal ; P, performance ; F, full.
[d]t-test.
[e]$\chi^2$-test.
*p<0.05, **p<0.01 (fit vs. non-fit). (Nakamura et al. 1992)

**Table 6. MFS at the start of occupational therapy (MFS-1) and 7 weeks after (MFS-2), and its difference (ΔMFS) of the fit and non-fit groups**

| | Fit | Non-fit |
|---|---|---|
| MFS-1 | 33.5±29.1[a] | 17.9±30.3 |
| MFS-2 | 52.0±30.5 | 19.2±31.5 |
| ΔMFS | 18.5±12.3 | 1.3±2.9 |

[a]The mean±S. D.
(Nakamura et al. 1992)

(p<0.01), suggesting that the recovery process of MFS is mostly typical and predictable in the patient without cortical lesions.

From the data of 125 patients belonging to the fit group, determinants of parameter A and B of the hyperbolic function, y=A−B/x, and 2 B/A, the time at which MFS reached to A/2, were estimated using stepwise regression analysis with the following independent variables : age, TSO, grip strength

**Table 7. The numbers of patients classified into the two groups, with (+) and without (−) lesions, by CT findings in the fit and non-fit groups**

| | Fit (n=125) | Non-fit (n=49) |
|---|---|---|
| CT findings | Lesion<br>+ : − | Lesion<br>+ : − |
| Frontal lobe | 24 : 101 | 22 : 27** |
| Cortex except frontal lobe | 35 : 90 | 20 : 29 |
| Internal capsule | 71 : 54 | 32 : 17 |
| Basal ganglia | 68 : 57 | 29 : 20 |
| Thalamus | 31 : 94 | 10 : 39 |
| Cerebellum and brainstem | 11 : 114 | 4 : 45 |

**p<0.01 ($\chi^2$-test).

(Nakamura et al. 1992)

of the affected hand, and MFS at the admission. The results revealed that

(i) parameter A could be estimated by age, TSO, grip strength and MFS ($R^2=0.59$),

(ii) parameter B by TSO ($R^2=0.62$), and

(iii) 2 B/A by TSO and MFS ($R^2=0.84$).

## [4] How to Approximate the Relationship Between TSO and MFS to the Hyperbolic Function

Although the approximation of the relationship between TSO and MFS to hyperbolic function is possible with two MFT-data of different weeks, utilization of more than four MFT-data is preferable to obtain an equation for a patient, which is relatively accurate for the prediction of future MFS's. Practically, five MFT-data could be gathered within 4 weeks during occupational therapy, which are sufficient for the prediction of outcome. The approximation to the hyperbolic function, $y=A-B/x$, is performed by means of a linear regression between the reciprocal number of TSO and MFS. In the equation, y is MFS and x is TSO (weeks).

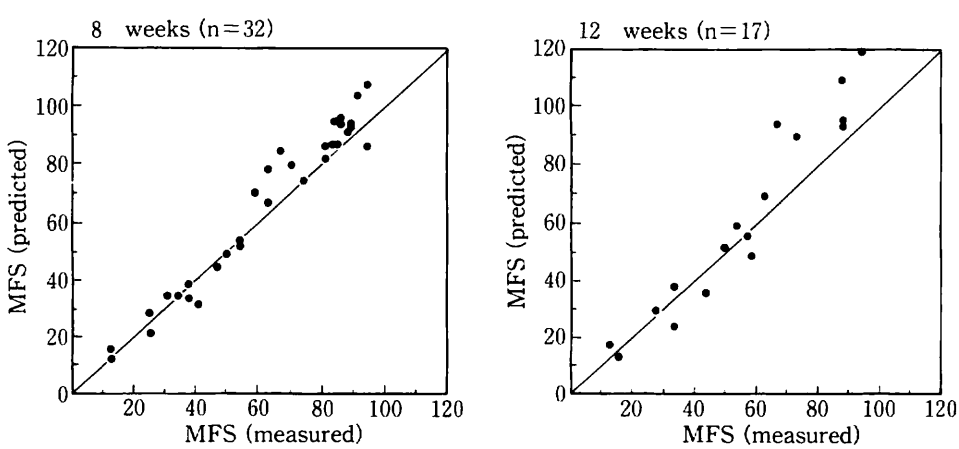



**Figure 9. Relationship between measured and predicted MFS**

From five MFS obtained during 4 weeks, approximation of the relationship between TSO and MFS to hyperbolic function was performed. Using the hyperbolic function thus obtained, MFS at 8 and 12 weeks later was calculated for each patient.

(Nakamura et al. 1991)

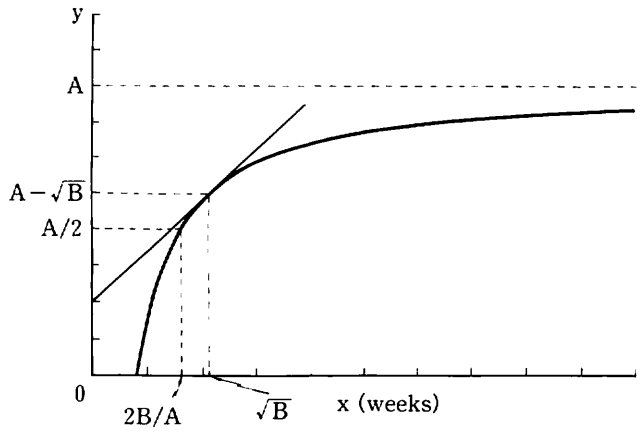



**Figure 10. Variables predicted by the use of hyperbolic function. See text.**
(Nakamura et al. 1991)

Here, y=MFS, x=TSO, and there is a substitution of x to 1/X.

Then, y=A−B/x is transformed into y=A−BX. In this way, the parameters A and *B* are determined.

Figure 9 presents the relationship of measured MFS and predicted MFS from the equation calculated using 4 weeks' data at 8 and 12 weeks after starting occupational therapy. In patients with MFS more than 90 at 12 weeks, the difference between the measured and predicted MFS is rather large. According to our clinical experience, patients with MFS more than 80 use their affected upper extremity in daily life activities. It is recommended that use of the prediction of MFS's be limited to patients whose predicted MFS is less than 90.

When the hyperbolic function obtained by the approximation is statistically significant, we can estimate following variables. In Figure 10, we substitute 80 for A and 321 for B. A is asymptotic value, presenting attainable MFS in future. A/2 is a half of the attainable MFS, and 2 B/A is TSO (weeks) when MFS will be A/2. $A-\sqrt{B}$ and $\sqrt{B}$ indicate the point at which the tangent line, y=x+C, comes into contact with the hyperbolic curve, y=A−B/x. Around this point, the gain of MFS would be 1/week. Before this point, the gain of MFS could be more than 1/week, and after the point, less than 1/week. The hyperbolic function reveals that a small 2 B/A corresponds to quick recovery of MFS and a large one to slow recovery.

# 3 OCCUPATIONAL THERAPY PROGRAM BASED ON MFT-S RECOVERY PROFILE

It is important to facilitate functional recovery as fast as possible after a stroke. For that purpose, we developed the "Program based on MFT-S Recovery Profile", with the assumption that motor recovery of the affected upper extremity follows a predictable pattern. In this program, therapeutic activities or tasks selected by occupational therapists-in-charge are determined with reference to the patient's MFT-S Recovery Profile (Figure 3).

## [1] Selected Activities Based on MFT-S Recovery Profile

We gathered retrospectively the activities or tasks which were assigned to hemiparetic patients with diverse MFT-S's, and attempted to find out the rule of activity selection (Moriyama et al. 1997).

Activities used in every session of occupational therapy were collected from therapists' records of 48 stroke patients aged from 30 to 80 years, without apraxia, agnosia and severe aphasia. The time since onset (TSO) ranged from one to 25 weeks, and the initial MFT-S ranged from 0 to 31. The patient underwent an occupational therapy program based on his/her MFT-S Recovery Profile for 3 to 8 weeks. MFT was examined once a week. The relationship between TSO and MFS was well approximated to the hyperbolic function in every patient (Morita et al. 1995).

Figure 11 presents the relationship between activities and MFT-S's. The selected activities are classified into two groups : one mainly performed with arm motions of the affected side (A) and the other with manipulative activities (B). Group A consists of six activities performed with the affected upper extremity. Activities for patients with low MFT-S's are mostly carried out with the shoulder and elbow movements, e. g., sanding. Activities for patients with high MFT-S's are performed by the hand and/or upper extremity such as moving a wooden-block. Activities for group B include handicrafts, and are classified into three classes. In handicraft 1, the affected upper extremity is used only to hold an object, e. g., lacing. In handicraft 2, the affected upper extremity is used for simple repetitive motions, e. g., sawing. In handicraft 3, the affected upper extremity is used for bilateral compound motions, e. g., handloom weaving. Patients with low MFT-S's perform handicraft 1, and those with high MFT-S's carry out mostly handicraft 3.

## [2] Selection of Activities

The following examples show the processes on how activities are selected by occupational therapists.

**Case 1.** A 60 year old male, rice dealer.

Diagnosis : Cerebral hemorrhage.

Complication : Hypertension.

Impairments : Left-sided hemiparesis and moderate sensory disturbances.

Figure 12 presents the relationship of MFS to TSO, indicating a significant approximation of the relationship to the hyperbolic function. Figure 13 shows his MFT-S Recovery Profile Chart, and Figure 14 presents activities used in his program for 8 weeks. The initial MFT-S is 12 (MFS : 32).

| MFT-S | 0~5 | 6~11 | 12~17 | 18~22 | 23~28 | 29~32 |
|---|---|---|---|---|---|---|
| Number of session | 32 | 39 | 30 | 40 | 53 | 27 |
| Wa-utsushi (move a quoit) | ▲▲ | ▲▲▲ | ▲▲▲ | ▲▲▲ | ▲ | |
| Move forward | | | | | | |
| Active-assisted (self-assisted) | **** | **** | * | * | | |
| Active-assisted (forearm supported) | ** | ***** | *** | | | |
| Active | | | **** | **** | * | |
| Move backward | | | | *** | * | |
| Protective extension of the affected upper extremity | ▲▲ | ▲▲ | ▲▲ | ▲ | ▲ | |
| Sanding : | ▲▲ | ▲▲ | ▲▲ | ▲▲▲ | ▲▲▲ | ▲▲▲ |
| Active-assisted (self-assisted) | **** | ***** | **** | ** | | |
| Active | | * | ** | *** | **** | *** |
| Resisted (loaded) | | | | ** | ***** | **** |
| Wooden block : | ▲ | ▲ | ▲▲ | ▲▲▲ | ▲▲▲ | ▲ |
| Move forward | | | | | | |
| Active-assisted | *** | *** | | | | |
| Resisted and active-assisted | | | ** | | | |
| Resisted and active | | | *** | ****** | *** | |
| Move backward | | | | * | **** | *** |
| Screw a wooden-block | | | | | ** | *** |
| Peg board | | | ▲ | ▲▲ | ▲▲▲ | ▲▲▲ |
| Wooden peg ($\phi$ 30mm) | | | *** | | | * |
| Wooden peg ($\phi$ 15mm) | | | | * | *** | |
| Metal peg ($\phi$ 5mm) | | | | ** | *** | **** |
| Purdue Pegboard | | | | | ** | **** |
| Remedial apparatus : | | | | | ▲ | ▲▲ |
| To toss or to throw a ball | | | | | * | |
| To grasp a falling pole | | | | | * | |
| To play deck quoits | | | | | | ***** |
| Handicraft 2 | ▲ | | ▲ | ▲ | | |
| Lacing | *** | | * | ** | | |
| Metal work 1 | | | ** | | | |
| Handicraft 2 | | | ▲ | ▲ | ▲▲▲ | ▲▲ |
| Stamping | | | ** | * | **** | * |
| Drawing | | | * | ** | ** | * |
| Sawing | | | | | | |
| Metal work 2 | | | | | | * |
| Personal computer, word processor | | | | | | |
| Handicraft 3 | | | | | ▲ | ▲▲▲ |
| Chigirie, Origami (art of holding paper into various figures), Mosaic, Wood engraving, Lacing, Handloom weaving, Beading, Ceramic art, Woodwork, Macrame, Sashiko, Artifical paper flower, Leather craft, etc. | | | | | | |

Percent of the patients performing the activity : ▲25~49% ▲▲50~74% ▲▲▲75~100%
*corresponds to 10% of the patients performing the activity. **to 20%, and so on.

**Figure 11. Relationship between MFT-S and activities selected by occupational therapists**

(Morita et al. 1995)

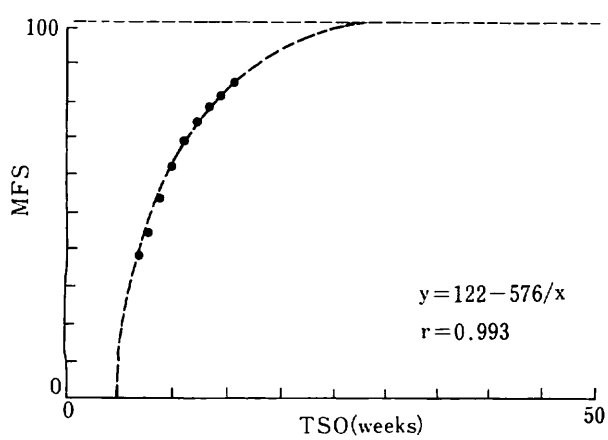



**Figure 12. Relationship between TSO and MFS of case 1**

The time since stroke onset to start of occupational therapy was 7 weeks.

(Moriyama et al. 1994)

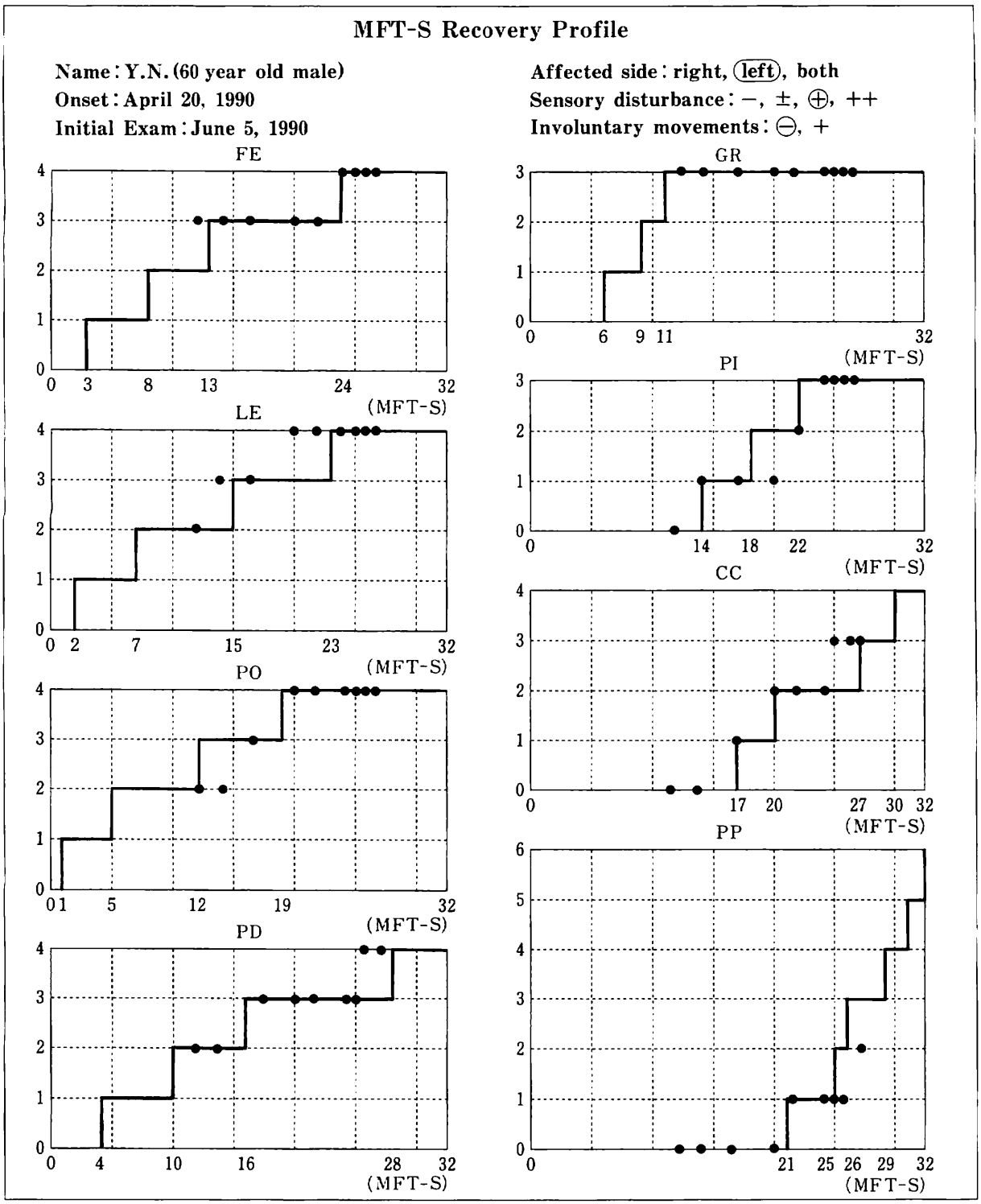



**Figure 13. MFT-S Recovery Profile Chart of case 1**

(Moriyama et al. 1994)

The task scored above the standard value is FE (forward elevation of the upper extremity) and the score of other tasks coincides with the standard value. After one week, the task scored above the standard is LE (lateral elevation of the upper extremity), and the task scored below the standard is PO (touch the occiput with the palm). After 3 weeks, MFT-S is 20 (MFS : 63), and the score of PI (pinch) remains below the standard. The occupational therapist prepares a program for the next

| Tasks | 1w | 2w | 3w | 4w | 5w | 6w | 7w | 8w | 9w |
|---|---|---|---|---|---|---|---|---|---|
| Wa-utsushi (self-assisted) | ○ | ○ | ○ | | | | | | |
| Protective extension of the affected upper extremity | ○ | ○ | ○ | | | | | | |
| Sanding (self-assisted) | ○ | ○ | | | | | | | |
| Wa-utsushi (active) | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Wooden block (active-assisted) | | ○ | ○ | | | | | | |
| Sanding (active) | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Wooden block (move backward) | | | | ○ | ○ | ○ | ○ | ○ | ○ |
| Stamping | | | | ○ | ○ | | | | |
| Peg board ($\phi$ 15mm) | | | | | | ○ | ○ | ○ | ○ |
| Handloom weaving | | | | | | ○ | ○ | ○ | ○ |
| Origami | | | | | | | | | ○ |
| Personal computer | | | | | | | | | ○ |

**Figure 14. Programs based on MFT-S Recovery Profile for case 1**
(Moriyama et al. 1994)

week which aims to increase the active range of motion (ROM) of the affected upper extremity, and muscular strength for the grasp. Selected activities are Wa-utsushi (move a quoit ; move forward-active), Sanding (loaded), Wooden block (move backward), and Stamping. MFT-S is 27 (MFS : 84) at discharge.

**Case 2.** A 51 year old male, carpenter.

Diagnosis : Cerebral hemorrhage.

Impairments : Right-sided hemiparesis and moderate sensory disturbances.

Figure 15 presents the result of initial MFT superimposed on MFT-S Recovery Profile. The initial MFT-S is 12. The tasks scored below the standard value are FE (forward elevation of the upper extremity) and PD (touch the dorsum with the palm). The score of PI (pinch) is above the standard. To facilitate discrete movements of the affected upper extremity and the finger tip pinch, programs utilizing bilateral compound motions are prepared for the next week.

Task 1. Wa-Utsushi (move a quoit ; active-assisted by a suspension sling) : The patient holds a quoit with the affected hand, carries it toward a pole, and sets it. The pole will be extended till the angle of active flexion of the shoulder reaches to 90 degrees.

Task 2. Wa-Utsushi (move a quoit ; move backward) : The patient takes up a quoit on the table with the right hand, and holds it. He moves the affected upper extremity backward as an active assisted motion, holding the quoit. Then he transfers the quoit to the left hand behind his trunk. Gradually the point of transfer moves to the midline of the dorsum.

Task 3. Lacing : He holds a leather sheet on the right hand, and laces a cord through holes with the left hand.

**Case 3.** A 67 year old male, retired.

Diagnosis : Cerebral hemorrhage.

Complication : Hypertension.

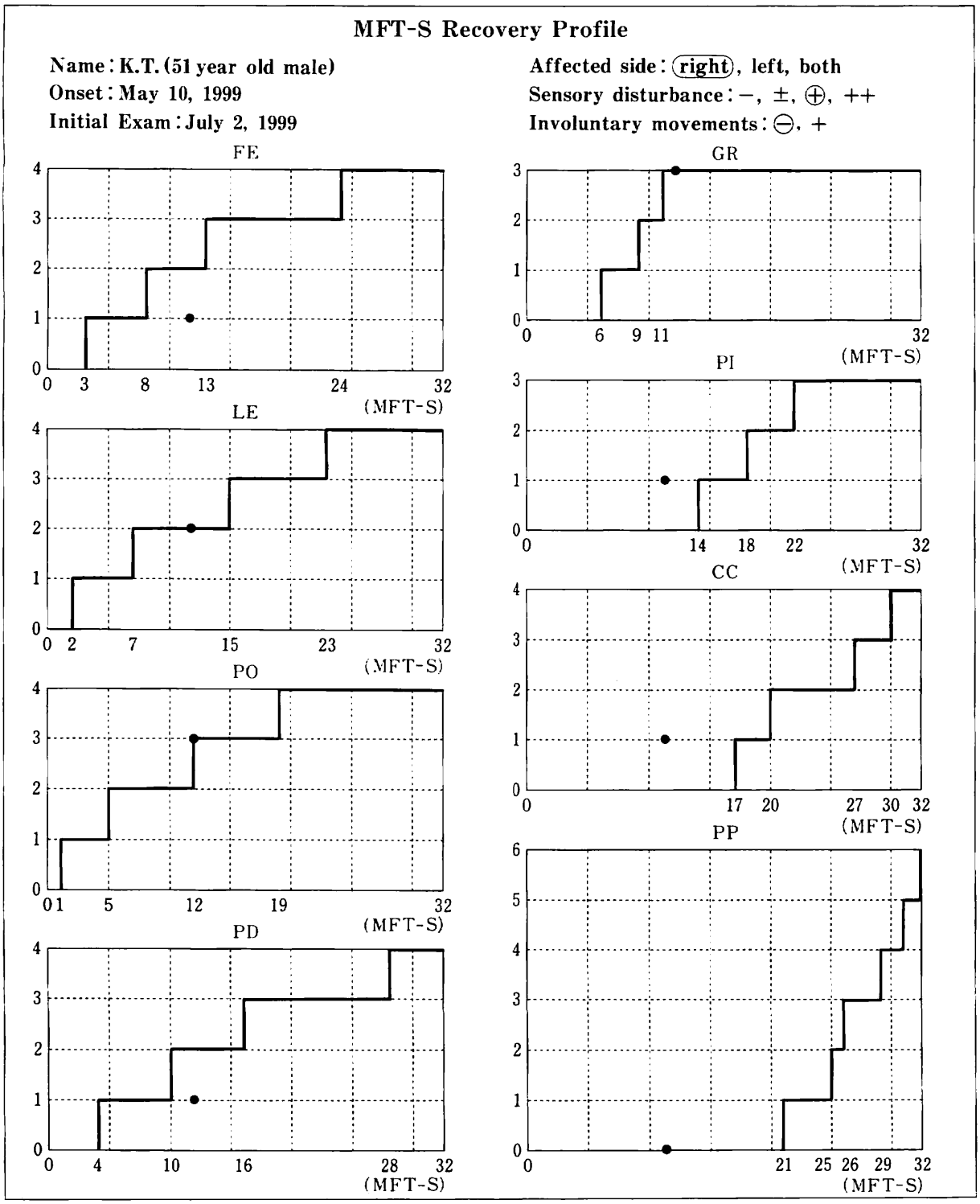



**Figure 15. MFT-S Recovery Profile Chart of case 2**

Impairment : Right-sided hemiparesis.

Figure 16 presents his MFT-S data on MFT-S Recovery Profile Chart. The initial MFT-S is 27. The score of PP (peg-board) is lower compared to the standard value. Although discrete movements of the affected upper extremity and fingers are possible, performance with the thumb and fingers is clumsy partly due to flexor synergic movements. The occupational therapist selects activities requiring coordinated movements of the upper extremity and fingers in program for the next week.

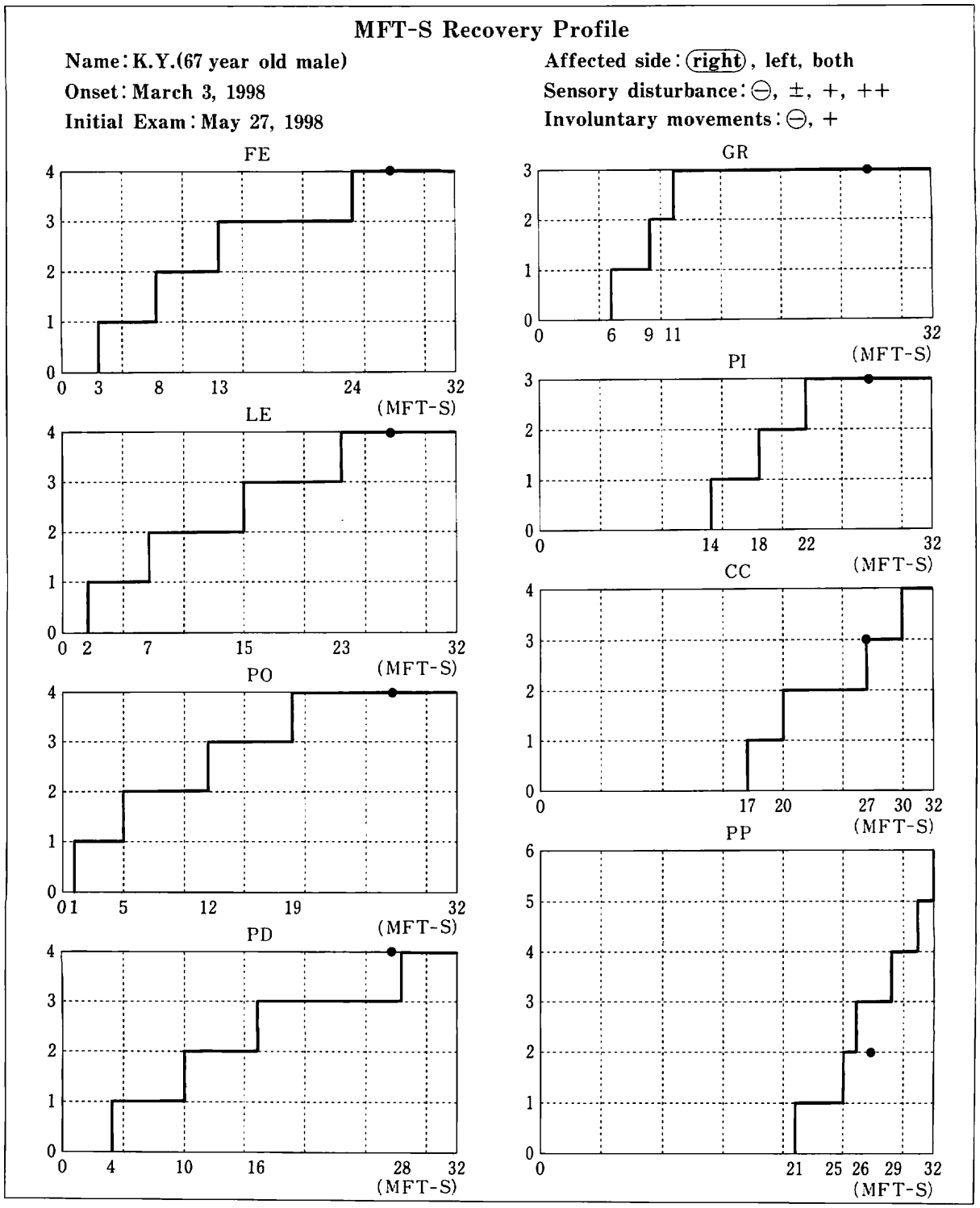



**Figure 16. MFT-S Recovery Profile Chart of case 3**

Task 1. Stamping : The patient holds a wooden stamp in cylinder form (diameter : 3 cm, length : 10 cm) with the thumb and fingers, and stamps on a paper attached to the wall.

Task 2. Drawing : He draws figures with a pencil, and paints outline drawing for coloring.

Task 3. Macrame : He knits a macrame. To perform this handicraft, skilled pinch and coordinated motion of bilateral hands are necessary.

## [3] Case Reports

We present two cases wherein the recovery process is followed up.

**Case O. K.** A 56 year old male, office manager

Diagnosis : Cerebral infarction

Complication : Hypertension

Impairments : Right-sided hemiparesis and sensory disturbance

Present illness : On 12 August 1999, he suddenly noticed dysesthesia and weakness of the right extremities associated with difficulty of speech during office work. He was transferred to an emergency hospital and diagnosed as right hemiplegia due to cerebral infarction in the left corona radiata. Consciousness was clear all throughout his illness. One week after the admission, he started to walk around the bed. Slight movements of the right shoulder became possible 10 days thereafter. On 9 September, he was transferred to the hospital unit of the National Rehabilitation Center for the Disabled. At admission, he could walk around the ward without a cane, and his Barthel index score was 100. Accordingly, the aim of rehabilitation as inpatient was to improve motor function of the affected right upper extremity within one month.

Initial assessment (the affected upper extremity) : Passive ROMs of the shoulder, elbow and wrist joints were within normal range. He complained of slight to moderate dysesthesia of fingertips. Discrete movements of the shoulder and the elbow joint were possible. He could not voluntarily extend the wrist joint. Voluntary movements of the middle to the little fingers were moderately limited in both flexion and extension. As for the thumb and the index finger, only slight flexion was noticed, when he exerted moderate efforts. MFS was 50 (MFT-S : 16). As shown in Figure 17, PI (pinch) was below the standard value. According to the RES, the predicted MFS (MFT-S) 4 weeks later was 63 (20), suggesting that he could pick up a pencil and write a few letters with it.

Plan and tentative goal : It was assumed that he could extend the right wrist and fingers, and perform activities using pulp pinch. Occupational therapy, 5 days/week with each session lasting 60 min, was prescribed. The therapy program was modified every week after MFT.

Clinical course (Figure 18) : The aims of the occupational therapy program for the first week were to facilitate voluntary control of shoulder flexion, elbow extension, wrist extension at neutral position of the forearm, and pulp pinch with the thumb and fingers. The following activities were selected :

Task 1. Stamping (diameter : 3 cm, length : 10 cm). The occupational therapist assisted the motion, holding his wrist at the extended position. One session consisted of 10 trials. He completed five sessions in each day.

Task 2. Wooden peg board (diameter : 3 cm). The occupational therapist prepared 20 wooden pegs which stood on a board. The patient picked up a wooden peg with the pulp pinch, carried it to a saucer, and released it into the saucer, one by one. He performed the activity for five sessions every day.

After one week, the score of PO (touch the occiput with the palm) increased from 3 to 4, and the score of PI (pinch) rose from 0 to 1. The aims of the program for the succeeding weeks were to improve the function of pulp pinch as well as the coordinated movements of the affected upper

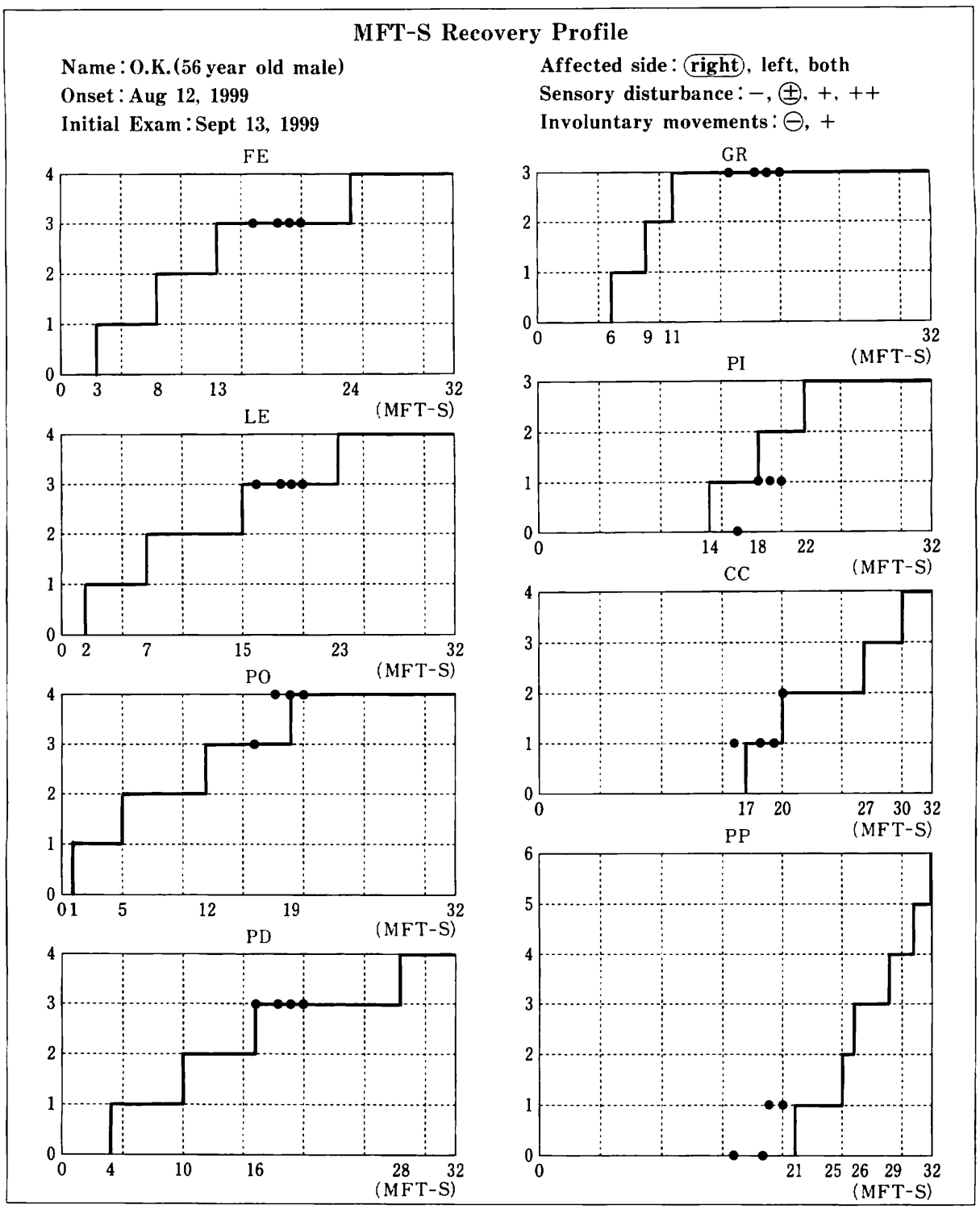



**Figure 17. MFT-S Recovery Profile Chart of the patient, O. K.**

extremity. The following activities were selected :

Task 1. Wooden peg board (diameter : 1.5 cm). The procedures were the same as above except for the size of the peg.

Task 2. Wooden block (move backward). The patient stood in front of a 45° tilted board, on which 25 wooden blocks were attached with Velcro. He wore a wide cloth belt with Velcro on the trunk. He picked up a wooden block with his affected hand using pulp pinch, carried it to his back and

| Date | Sept 13 | Sept 20 | Sept 27 | Oct 4 |
|---|---|---|---|---|
| MFS | 50 | 56 | 59 | 59 |
| MFT-S | 16 | 18 | 19 | 19 |
| Tasks | | | | |
| Stamping | ○ | | | |
| Wooden-peg ($\phi$ 30mm) | ○ | | | |
| Wooden-peg ($\phi$ 15mm) | | ○ | ○ | |
| Wooden block | | ○ | ○ | ○ |
| Drawing | | ○ | ○ | ○ |
| Metal-peg ($\phi$ 5mm) | | | | ○ |

**Figure 18. Activities selected by the occupational therapist for the patient, O. K.**

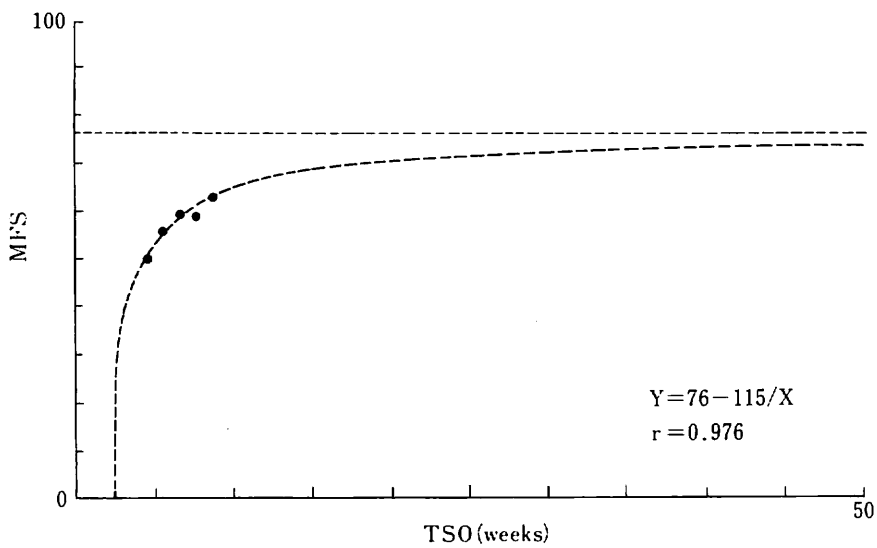



**Figure 19. Relationship between TSO and MFS of the patient, O. K.**

attached it on the cloth belt. Then, he took off the wooden block from the cloth belt with the non-affected hand. One session consisted of 25 trials. He performed three sessions each day.

Task 3. Drawing. He wrote 50 lines of horizontal, vertical and oblique directions on white paper with a felt-tip pen.

Three weeks later, MFS (MFT-S) was 59 (19). The score of PI was below the standard value. In order to restore accurate pulp pinch, the occupational therapist changed the peg and board from wooden to metal, with the metal peg (diameter : 0.5 cm).

Final assessment : Four weeks after admission, his MFS (MFT-S) was 63 (20). Compared to the standard value, the score of PI was low and the score of PP was high. He could write a few letters with a pencil. The relationship between TSO and MFS is shown in Figure 19.

He was discharged on 13 October, and continued to undergo occupational therapy services as an outpatient.

**Case T. M.** A 51 year old female, housewife

Diagnosis : Cerebral infarction

Complication : Hypertension

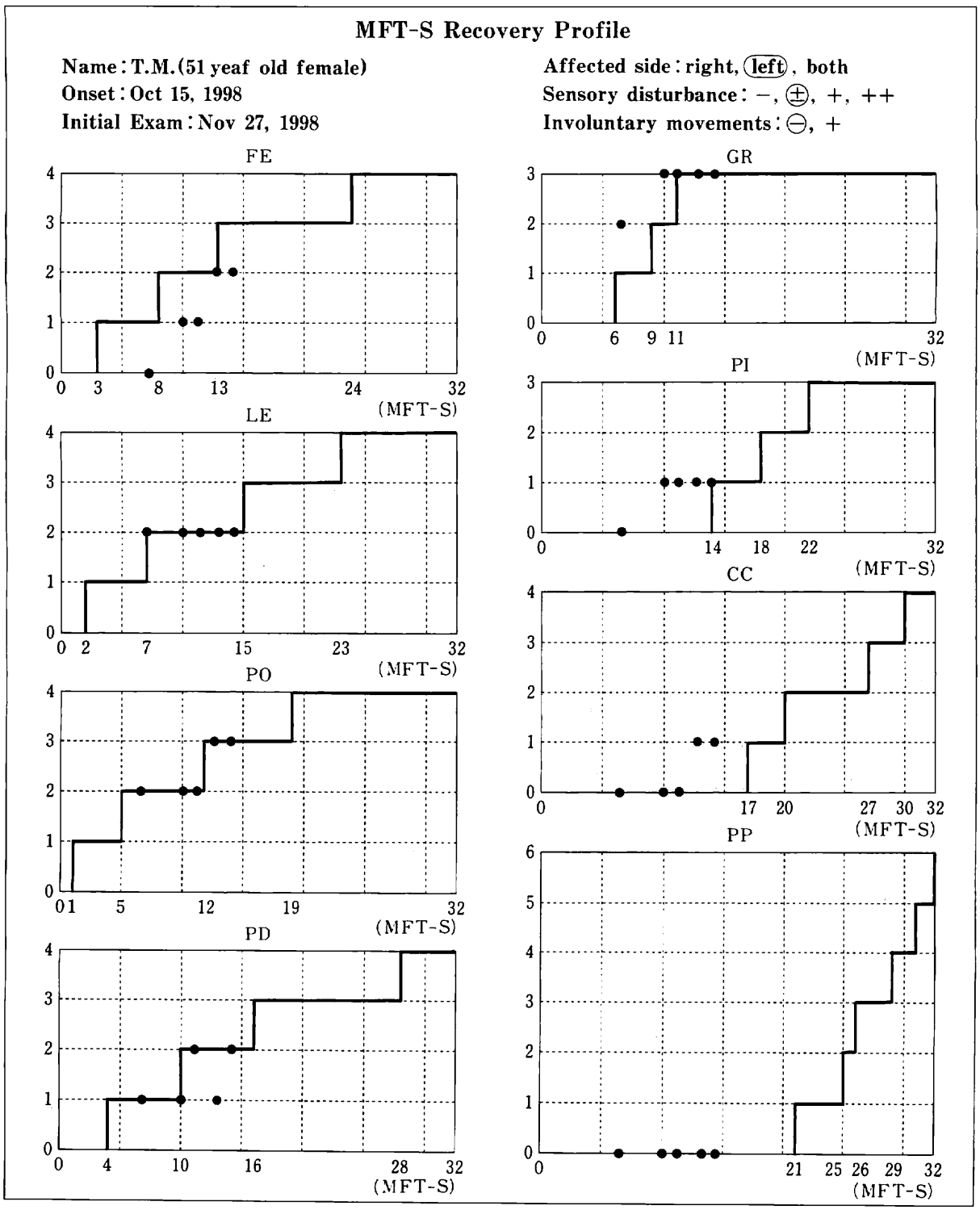



**Figure 20. MFT-S Recovery Profile Chart of the patient, T. M.**

Impairments : Left-sided hemiparesis and sensory disturbance

Present illness : On 15 October 1998, the patient noticed left-sided dysesthesia after supper. The next morning, she could not walk alone and was admitted to a hospital. CT scan revealed a low density area in the right internal capsule, indicating cerebral infarction. At that time she could not voluntarily move her left upper and lower extremity. Consciousness was clear. Two weeks later, there appeared slight voluntary movements of the left lower extremity. One month later, she could

| Date | Nov 27 | Dec 4 | Dec 11 | Dec 18 |
|---|---|---|---|---|
| MFS | 22 | 31 | 34 | 41 |
| MFT-S | 7 | 10 | 11 | 13 |
| Tasks | | | | |
| Sanding (self-assisted) | ○ | | | |
| Wa-utsushi (active-assisted) | ○ | ○ | ○ | ○ |
| Wooden block (active-assisted) | | ○ | ○ | |
| Wooden-peg ($\phi$30mm) | | | | ○ |
| Lacing (leather coaster) | | | | ○ |

**Figure 21. Activities selected by the occupational therapist for the patient, T. M.**

voluntarily move her shoulder and elbow joints, although their active ROMs were very limited. On 24 November, she was transferred to the hospital unit of the National Rehabilitation Center for the Disabled.

Initial assessment : Functional assessments performed within one week after admission indicated that her Barthel index score was 55, and MFS (MFT-S) of the affected side was 22 (7) and that of the non-affected side was 100 (32). According to the RES prediction, the Barthel index score would be around 90 after 8 weeks. ROMs of the affected upper extremity were within normal range. Both superficial and deep sensations were slightly impaired. Active shoulder abduction, elbow flexion and finger flexion were partially possible. Compared to the standard value, the score of FE was low and the score of PI was high (Figure 20). Prediction of RES pointed out that MFS (MFT-S) of the affected side would be 34 (11) after 4 weeks of occupational therapy, indicating that she could perform forward elevation of the upper extremity more than 45 degrees, and also grasp a ball and hold it without assistance.

Plan and tentative goal : The aims of occupational therapy for the succeeding weeks were to increase active ROM of the shoulder, to regain voluntary finger-extension and grasp-release function. Occupational therapy, 60 min duration at a frequency of 5 days/week, was prescribed. Activities were modified every week after MFT.

Clinical course (Figure 21) : For the first week, the occupational therapy program aimed at the improvement of ROM for active forward elevation of the affected upper extremity. The following activities were selected :

Task 1. Sanding (self-assisted). The tilting angle of the sanding board was at 45 degrees. The patient sat on a chair. The left hand, with the fingers extended and abducted, was fixed to a sanding block with Velcro-band. Pushing up and pulling down of the block were mainly performed by the right hand. One session consisted of 10 trials, and five sessions for each day were prescribed.

Task 2. Wa-Utsushi (move a quoit ; active-assisted). The patient sat on a chair in front of a table, on which were 10 quoits and a pole. She grasped a quoit with the left hand and put it on the pole, while the left forearm was supported with a suspension sling (1.0 kg loaded). The occupational therapist guided the movement of the affected upper extremity. One session consisted of 10 trials, and five sessions were performed each day.

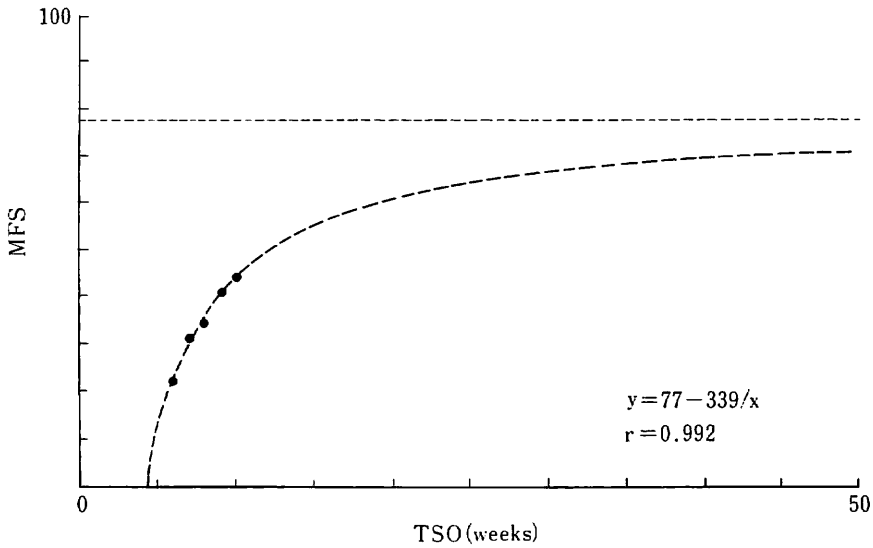



**Figure 22. Relationship between TSO and MFS of the patient, T. M.**

After one week, she could actively perform left shoulder flexion up to 40 degrees, grasp a ball while the forearm was supported, and pick up a pencil on the table. MFS (MFT-S) was 31 (10) . The score of FE was still less than the standard value. The aims of the occupational therapy program for 2nd and 3rd weeks were to further increase active ROM of the shoulder, and to improve the capacity for grasping, carrying and releasing objects. Activities were changed as follows :

Task 1. Wa-Utsushi (move a quoit ; active-assisted) . The left forearm was supported by suspension sling (0.8 kg loaded).

Task 2. Wooden block (move forward ; active-assisted). She sat on a chair in front of the table, on which were 10 wooden blocks (5 cm cube). The left forearm was supported by a suspension sling. She grasped a wooden block, carried it laterally and released it on the table. One session consisted of 10 trials. Five sessions were performed every day.

After 3 weeks, MFS (MFT-S) was 41 (13). FE reached the standard value. Also, she successfully performed CC-1, i. e., carried a 5 cm cube forward more than 10 cm whthin 5 sec.

The aim of the program for the 4th week was to improve pulp pinch with the thumb and fingers. Selected activities were :

Task 1. Wa-Utsushi (move a quoit ; active). One session consisted of 10 trials, and five sessions for each day were prescribed.

Task 2. Peg board. Twenty wooden pegs (3 cm in diameter, 8 cm length) stood on 36×28 cm board. She grasped one peg, carried the peg from board to saucer and dropped the peg. Three sessions were prescribed daily.

Task 3. Lacing. She laced a round leather coaster (9 cm diameter, 0.5 cm thickness), holding the leather with the left hand and inserting a leather string with the right hand.

Final assessment : Figure 22 presents the relationship between TSO and MFS. MFS (MFT-S) became 44 (14) after 4 weeks of occupational therapy. The score of CC (carrying a cube) was higher than the standard value. Although the score of FE was still lower than the standard, the short term goals, i. e., 60 degrees FE of the shoulder, voluntary finger extension and grasp-release function, were attained by the 4-week occupational therapy program.

# 4 APPENDIX

## [1] Process of Motor Recovery of the Affected Upper Extremity Revealed by EMG Polygraph

The relationship between MFS and the stage of motor recovery (Brunnstrom 1970) and EMG polygraph data were analyzed in 41 hemiparetic male patients aged 37 to 73 years. The time from the stroke onset to the EMG examination ranged from 4 to 23 weeks. The EMG examinations were repeated two or three times with 4 week intervals in 11 patients. The patient sat on a chair. The elbow joint of the affected side was passively kept at 90 degrees flexion with the forearm supinated or pronated by the examiner. The surface EMG activities picked up from the biceps brachii, triceps brachii, finger flexors and finger extensors, were amplified and recorded on an oscilloscope paper (Figure 23) . The patient was asked to flex or extend the wrist joint isometrically by pushing against the examiner's hand with moderate effort for at least 3 sec. He performed three trials in each position with intervals of more than 5 sec. The EMG activities greater than 0.02 mV during the performance were regarded as active contraction of the muscle. Table 8 schematically presents the synergic pattern of muscular activities in each task (Gellhorn 1947 ; Nakamura 1973). These patterns were used as reference. When muscular activities are observed where muscular activities are not present in the reference, they are referred to as the abnormal element. The muscular activities observed in

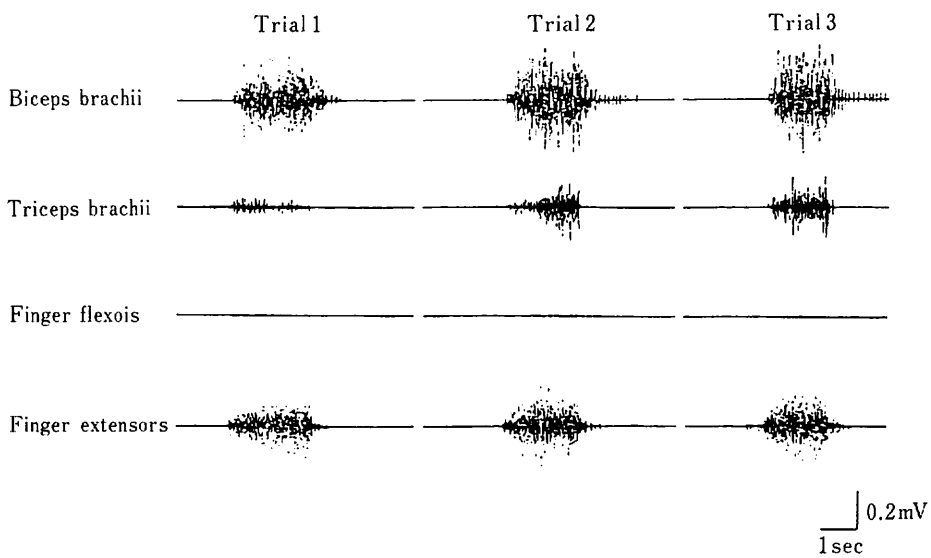



**Figure 23. EMG polygraph during wrist extension**

Electromyographic activities of the biceps brachii, triceps brachii, finger flexors and finger extensors are recorded during active wrist extension. Three trials are shown. Position of the upper extremity : the shoulder at kinesiological reference position, the elbw at 90 degrees flexion and the forearm at pronated position.
Patient : A 53 years-old, male. Left hemiparesis.
Overflow of muscular activities are observed in the triceps brachii. There is no abnormal activity in the finger flexors.

(Morita et al. 1992)

**Table 8. Synergic pattern of muscular activities in healthy Adults.**

| Forearm position | Supinated | | Pronated | |
|---|---|---|---|---|
| Movement task (wrist) | Flex | Extend | Flex | Extend |
| Biceps brachii | + | − | − | + |
| Triceps brachii | − | + | + | − |
| Finger flexors | + | − | + | − |
| Finger extensors | − | + | − | + |

(Nakamura 1973)

**Table 9. Relationship between the stage of motor recovery (Brunnstrom) and MFS**

| The stage (Arm) | n | MFS | | The stage (Fingers) | n | MFS | |
|---|---|---|---|---|---|---|---|
| | | Means | S. D. | | | Means | S. D. |
| 1 | 3 | 0 | 0 | 1 | 8 | 2.8 | 4.7 |
| 2 | 5 | 4.4 | 5.4 | 2 | 3 | 18.7 | 8.5 |
| 3 | 11 | 28.4 | 11.0 | 3 | 5 | 26.2 | 5.9 |
| 4 | 3 | 48.7 | 13.1 | 4 | 5 | 49.8 | 10.8 |
| 5 | 7 | 68.4 | 9.2 | 5 | 10 | 63.3 | 13.8 |
| 6 | 12 | 81.7 | 8.3 | 6 | 10 | 84.4 | 5.4 |

$r_s = 0.946$ $p < 0.01$ $r_s = 0.961$ $p < 0.01$

(Morita et al. 1992)

the same muscle as the reference were named the normal element. Then we count the number of abnormal and normal elements in the four tasks.

Table 9 shows the relationship between Brunnstrom's stage of motor recovery and MFS. Low MFS's (20-40) correspond to stage 3 of motor recovery and moderate MFS's (40-60) to stage 4, indicating that patients with low MFS's could move the affected upper extremity with synergic movement patterns and those with MFS's greater than 40 did so with discrete movement patterns. Figure 24 presents the relationship of MFS to the number of abnormal and normal elements for each patient. The relationship between MFS and the number of normal elements is significant in patients with MFS ranging from 0 to 30 ($p<0.01$), indicating that the increase of MFS is coupled to the increased number of normal elements. The number of normal elements reached the maximum level in patients with MFS greater than 30. In the patients with MFS less than 44, there was a significant correlation between MFS and the number of abnormal elements ($P<0.05$). On the other hand, in patients with MFS greater than 44, the relationship between the increase of MFS and the decrease of abnormal elements tended to be significant ($p<0.1$). Similar relations were observed between EMG data and the stage of motor recovery. In patients belonging to Brunnstrom's stage less than 3, progression of the stage was coupled to the increase of both abnormal and normal elements. Among the patients belonging to Brunnstrom's stage greater than 4, the number of normal elements were four, i. e., as same as the reference. The decrease of abnormal elements along with the progression of the stage were statistically significant in the arm, but not in the finger.

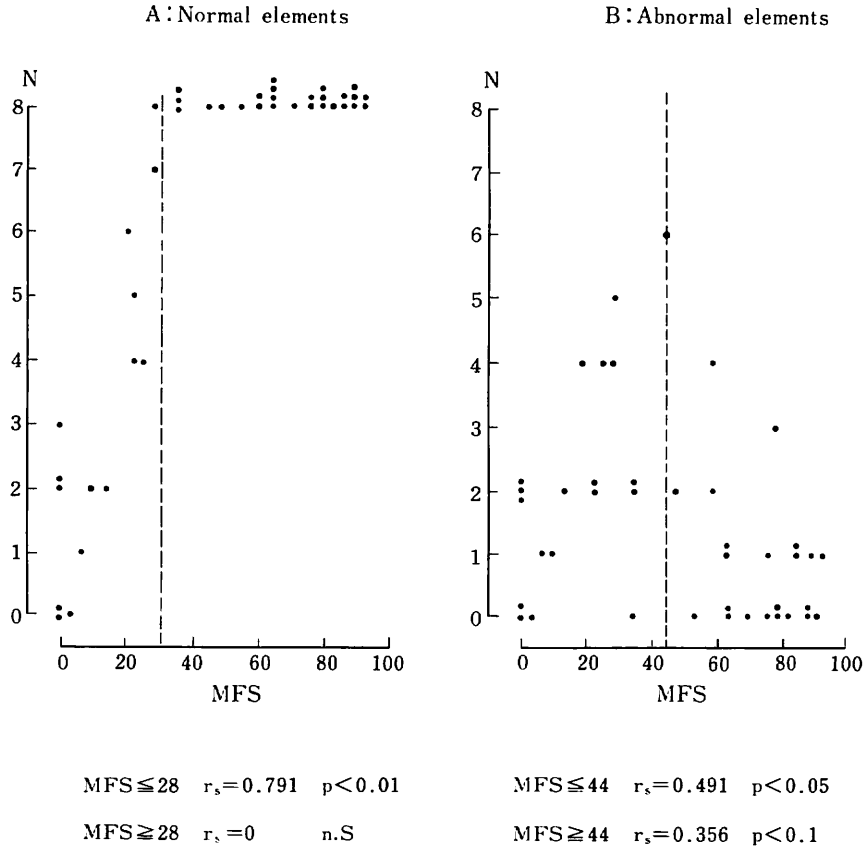



**Figure 24. The relationship of MFS to the number of normal and abnormal elements.**

(Morita et al. 1992)

## [2] Illustrative Activities

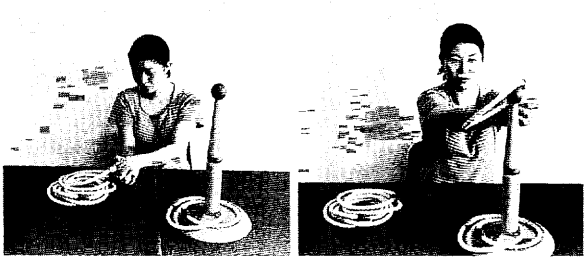
Throughout these illustrations, the affected side is the right.

### 1. Wa-utsushi (move a quoit)

**1) Move forward**

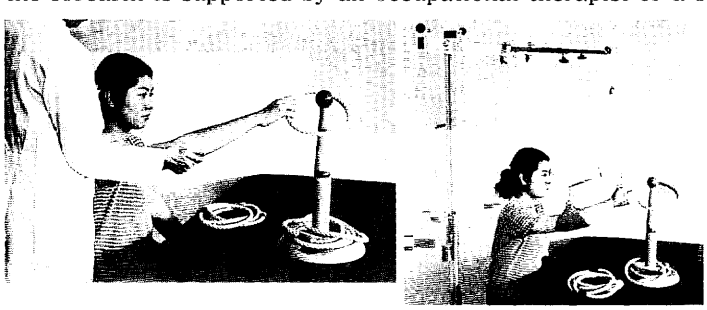
**A. Active-assisted movements (self-assisted)**

The patient clasps the both hands, and picks up a quoit on the table with the thumb and the index finger of the non-affected side. Then he/she moves the quoit to the pole, and sets them.



**B. Active-assisted movements (forearm supported)**

The patient grasps a quoit with the affected hand, moves it to the pole and sets them, while the forearm is supported by an occupational therapist or a suspension sling.

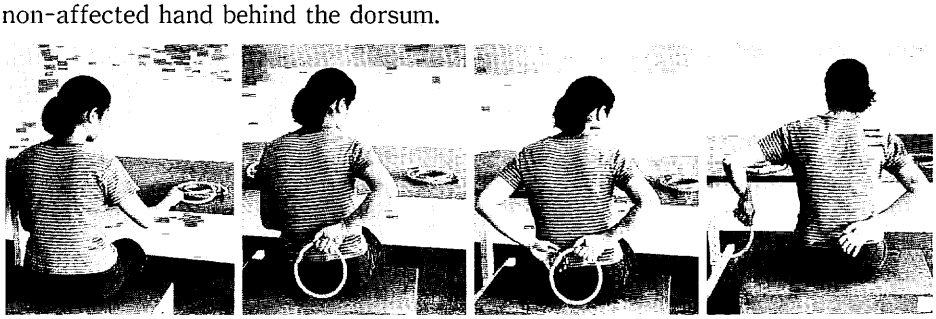


**C. Active movements**

The task is performed with the affected upper extremity. The height of pole should be adjusted within active ROM of shoulder flexion.

**2) Move backward**

The patient grasps a quoit with the affected hand, moves it toward his/her back, and transfers it to the non-affected hand behind the dorsum.

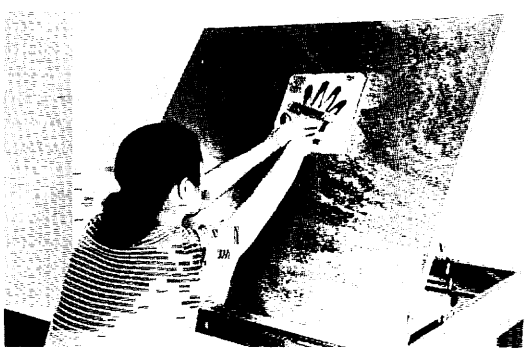


## 2. Protective extension of the affected upper extremity (partial support of the body weight)

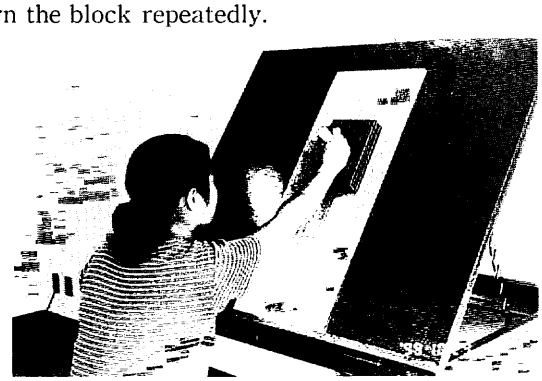
The patient sits on a long chair. While performing a task with the non-affected hand, he/she places the palm of the affected side on the chair with the extended elbow (partially supporting the body weight). The occupational therapist assists the elbow extension, if necessary.

## 3. Sanding

The patient performs the task with various sanding blocks. The slope of sanding board ranges from 0 to 55 degrees. He/she should push up and pull down the block repeatedly.

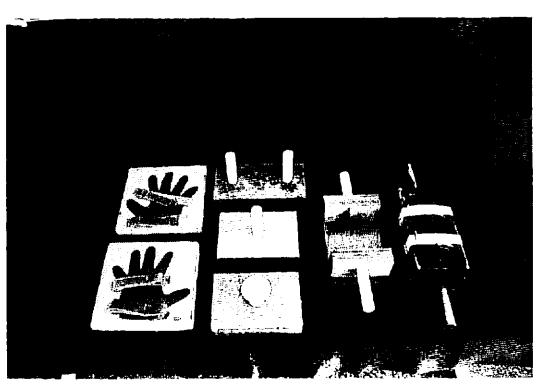


A. Active-assisted movements (self-assisted)



B. Active movements

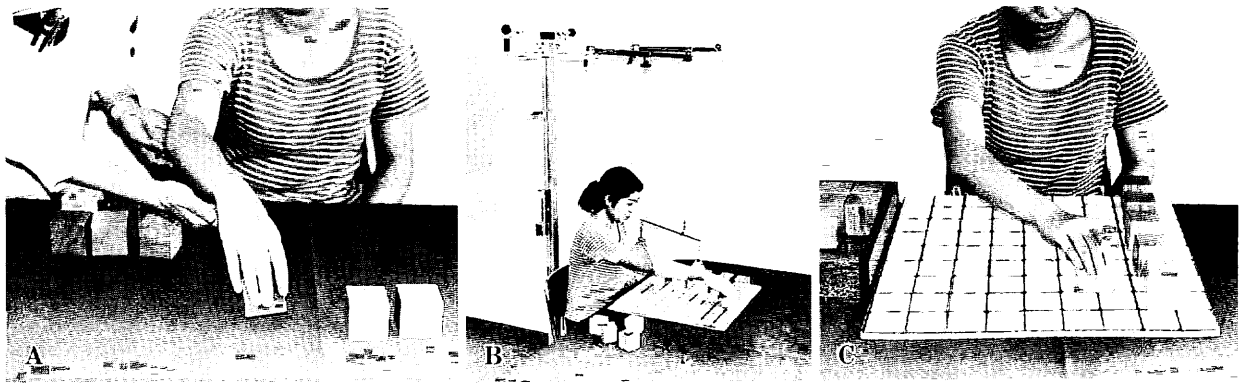
C. Resisted movements (loaded)



D. Various sanding blocks

## 4. Wooden block

### 1) Move forward




**A. Active-assisted movements**

The patient picks up a block on the table and moves it forward with the affected upper extremity. The occupational therapist supports the forearm during the performance.

**B. Resisted and active-assisted movements**

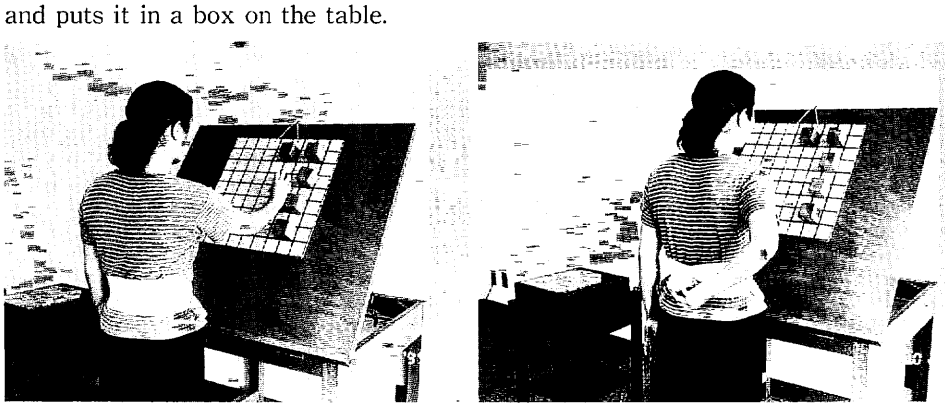
The motion of picking-up is performed against resistance of fixation by Velcro. The forearm is supported by suspension sling during task-performance.

**C. Resisted and active movements**

The task is the same as task B (resisted and active-assisted movements) except no support for the forearm.

### 2) Move backward

The patient wears a wide cloth belt with Velcro on the trunk. He/she stands in front of a tilted board, on which 25 wooden-blocks are attached with Velcro. He/she picks up one block with the affected hand, carries it toward the dorsum, and attaches it on the belt at the dorsum. Using the non-affected hand, he/she removes it from the belt, and puts it in a box on the table.

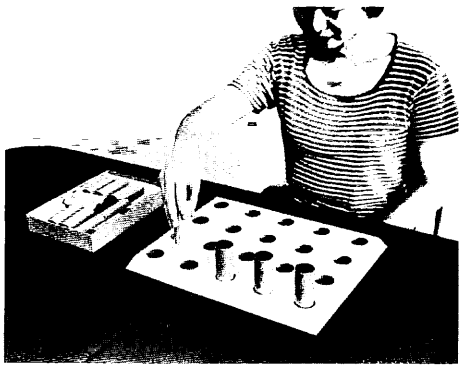


### 3) Screw a wooden-block

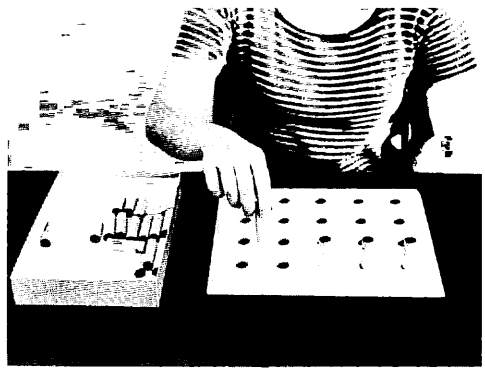
The patient screws a wooden-block attached on a tilted board with the pronation and supination.

## 5. Peg-board

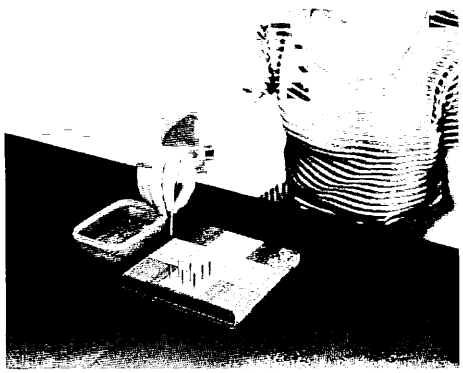
All tasks are performed by active movements.



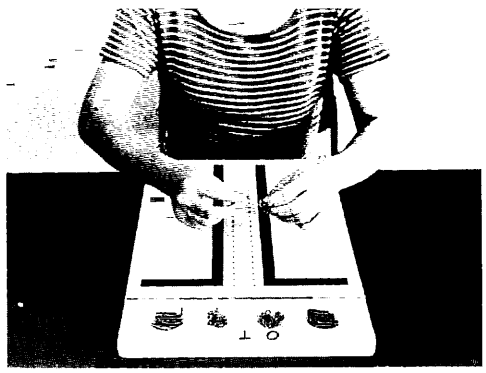
A. Wooden-peg ($\phi$ 30 mm) and board



B. Wooden-beg ($\phi$ 15 mm) and board



C. Metal peg ($\phi$ 5 mm) and board



D. Perdue Peg Board

## 6. Remedial apparatus

A. To toss or to throw a ball

B. To grasp a falling pole

C. To play deck quoits

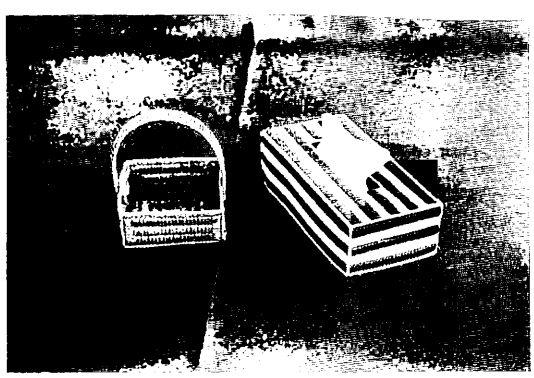
## 7. Handicrafts

Activities using handicrafts are divided into three groups, depending upon motions performed by the affected upper extremity.
Handicraft 1 : Activities of the affected upper extremity are to hold an object and to keep its position stationarily.
Handicraft 2 : The affected hand holds an object and the affected arm performs repetitive motions.
Handicraft 3 : The both upper extremities perform compound motions.

### 1) Handicraft 1

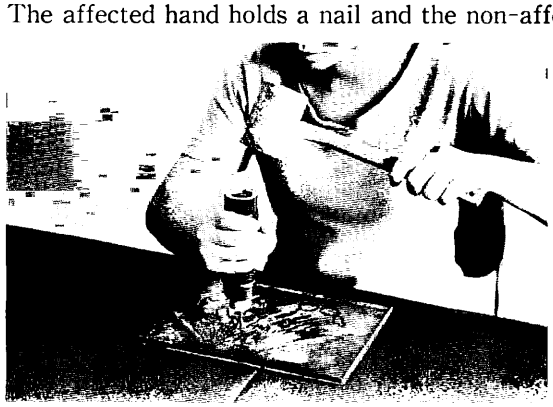
#### A. Lacing

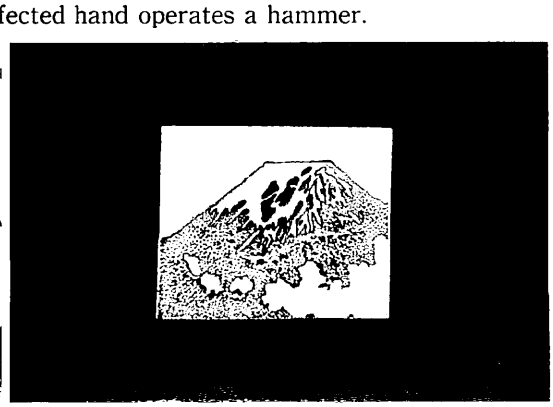
The affected hand holds a leather sheet stationarily during task performance.



#### B. Metal work

The affected hand holds a nail and the non-affected hand operates a hammer.

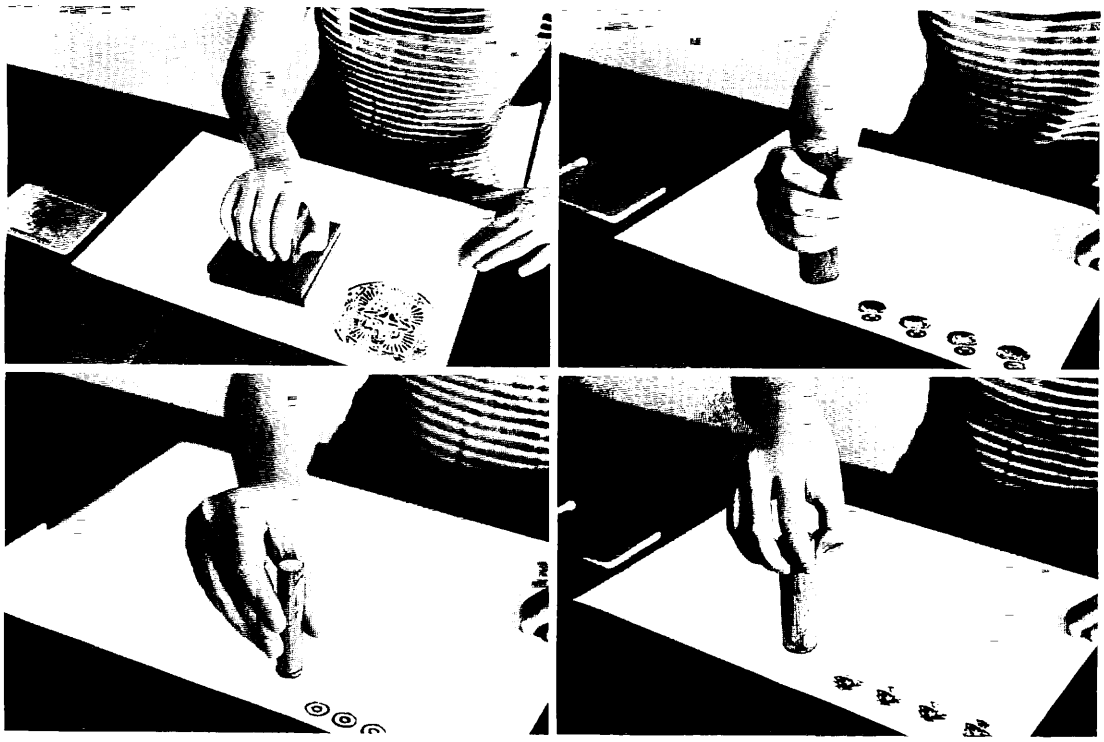




2) **Handicraft 2**

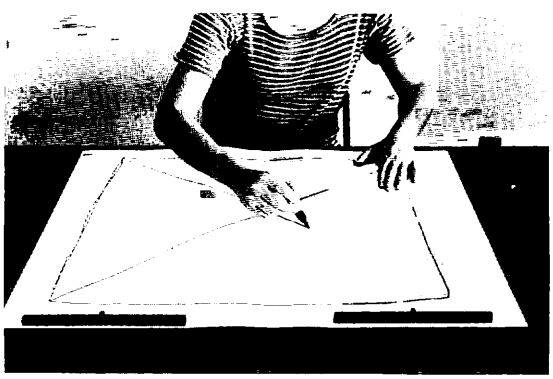
**A. Stamping**

The patient grasps or pinches a printing block and stamps on a paper repetitively.



**B. Drawing**

The patient draws lines with a felt pen.



**C. Sawing**

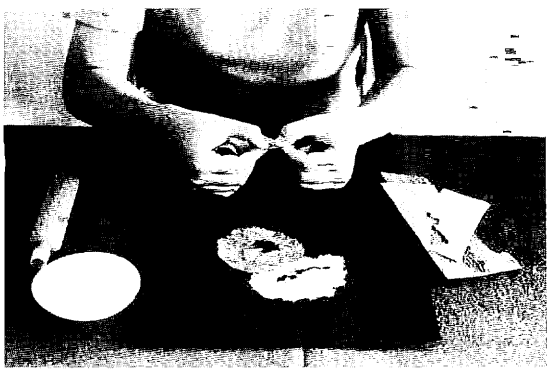
**D. Metal work**

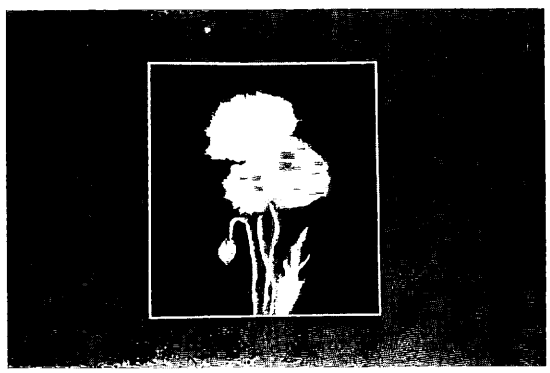
The patient holds a hammer with the affected hand and hits a nail with it.

### 3) Handicraft 3

**A. Chigirie**

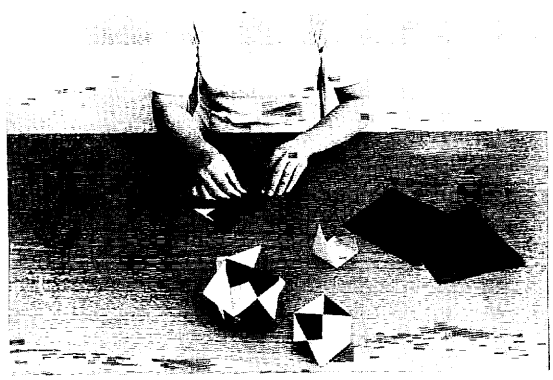
The art using Japanese paper (Wa-shi). The patient tears Japanese paper to peaces, and sticks them on a thick paper with paste, making a figure.



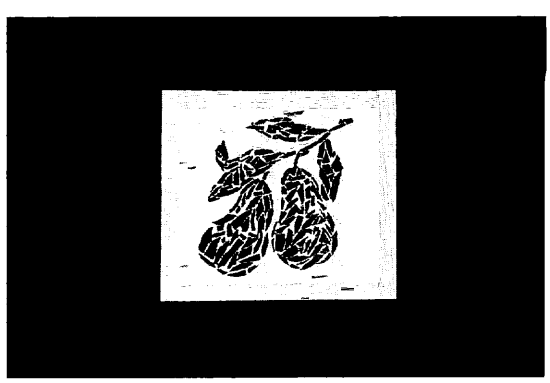


**B. Origami**

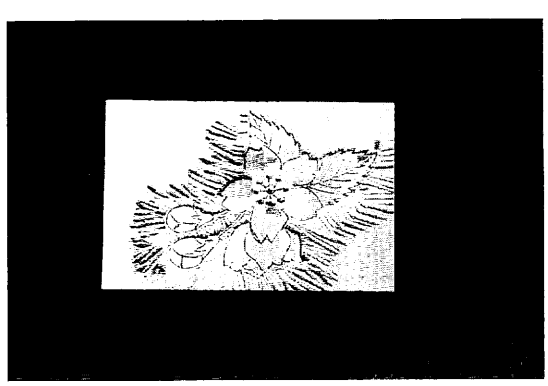
The art of folding paper into various figures. The coordinated manual movements of the both hands are necessary to perform these activities.



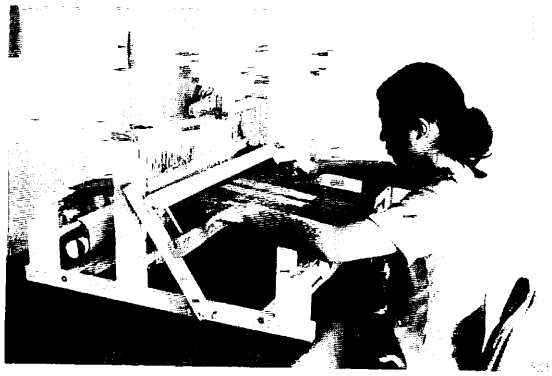
**C. Mosaic works using ceramic tiles**

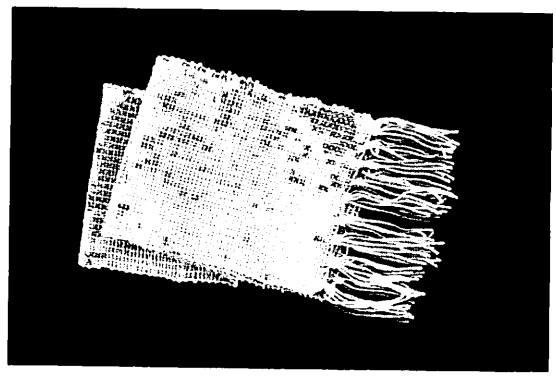


**D. Wood engraving**

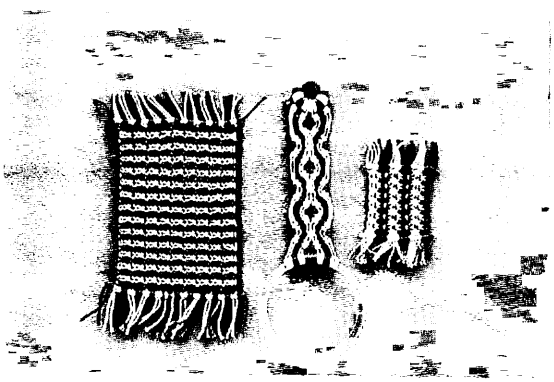


E. Handloom weaving

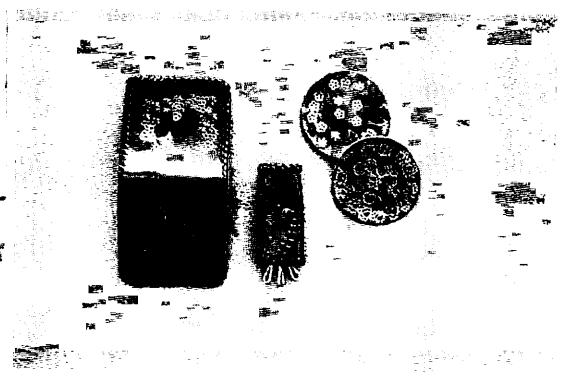




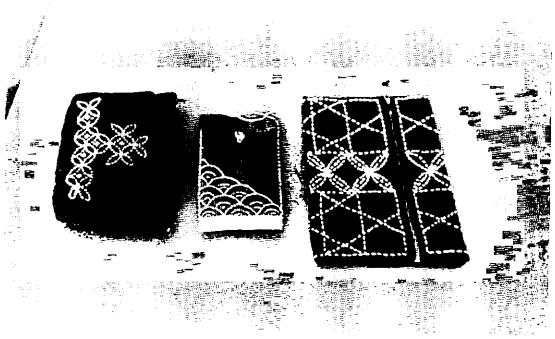
F. Macrame



G. Leatherworks



H. Sashiko (quilting)



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