Randomized, Controlled Trial to Evaluate Increased Intensity of Physiotherapy Treatment of Arm Function After Stroke

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Background and Purpose—Many patients have impaired arm function after stroke, for which they receive physiotherapy. The aim of the study was to determine whether increasing the amount of physiotherapy early after stroke improved the recovery of arm function and to compare the effects of this therapy when administered by a qualified therapist or a trained, supervised assistant. The physiotherapy followed a typical British approach, which is Bobath derived. Ten hours of additional therapy were given over a 5-week period.

Methods—The study design was a single-blind, randomized, controlled trial. Stroke patients were recruited from those admitted to the hospital in the 5 weeks after stroke. They were randomly allocated to routine physiotherapy, additional treatment by a qualified physiotherapist, or additional treatment by a physiotherapy assistant. Outcome was assessed after 5 weeks of treatment and at 3 and 6 months after stroke on measures of arm function and of independence in activities of daily living.

Results—There were 282 patients recruited to the study. The median initial Barthel score was 6.5, and the median age of the patients was 73 years. The median initial Rivermead Motor Assessment Arm score was 1. There were no significant differences between the groups at randomization or on any of the outcome measures. Only half of the patients allocated to the 2 additional-therapy groups completed the program.

Conclusions—This increase in the amount of physiotherapy for arm impairment with a typical British approach given early after stroke did not significantly improve the recovery of arm function in the patients studied. A number of other studies of interventions aimed at rehabilitation of arm function have reported positive results. Such findings may have been due to the content of these interventions, to the greater intensity of the interventions, or to the selection of patients to whom the treatments were applied. **(*Stroke*. 1999;30:573-579.)**

Key Words: rehabilitation ■ physiotherapy ■ stroke ■ upper limb

Most patients have impaired arm function after a stroke.[1] Some though not all of these patients regain function during the months after stroke.[2,3] Physiotherapy is usually given to enhance recovery, and some studies have shown that a specific rehabilitation program can increase the rate of arm motor recovery.[4,5]

In current rehabilitation practice, there may be inadequate stimulation of functional arm activities, whereas leg activities are more likely to be encouraged.[5] Gladman et al[6] described treatment in a group of patients receiving domiciliary therapy. Most treatment sessions were directed at gait training and mobility practice, and only a small proportion of the time was spent on arm function. Similarly, Kalra et al[7] reported less treatment for arm function than for lower-limb function and balance.

There are theoretical grounds for believing that early treatment is likely to be beneficial. With early treatment, it is likely that secondary musculoskeletal changes, the learning of abnormal movement strategies, and learned nonuse can be avoided. Secondary changes include adaptive changes to muscle length, which result in alterations of the length-tension curve of the muscle,[8] joint stiffness and pain,[9] and muscle atrophy. When patients are unable to use their affected arm, they compensate either by using the intact arm more, which can lead to learned nonuse,[10] or by using the affected arm as best they can, by learning abnormal compensatory movement strategies in the process, which can be difficult to change later.[11] Reviews of research in physiotherapy have concluded that treatment is more effective when commenced early after stroke onset.[12,13] Also, studies of primates[14] provide some indication that there may be a critical period for cortical plasticity related to the return of motor abilities in the upper limb.

In clinical practice, most patients are treated with specific neuromuscular facilitation techniques, the most commonly

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used in Britain being those proposed by Bobath.[15,16] In the Bobath approach, the aim is to improve coordination by obtaining normal active reactions of the affected side in response to being moved and to inhibit abnormal patterns of movement. Bobath techniques have not been fully compared with other approaches. Ernst,[13] in his review of physiotherapy treatment approaches, reports a few studies that have compared Bobath with alternative approaches, but actual results have failed to show any significant difference in outcome according to the approach used. However, the intensity of physiotherapy offered has been shown to have significant effects. Langhorne et al[17] conducted a meta-analysis of 7 randomized, controlled trials to compare the effects in groups receiving more and less intensive physiotherapy. They found a statistically significant reduction in the combined outcome of death or deterioration by the end of follow-up or death for more intensively treated patients. Kwakkel et al[18] used an alternate methodology in their meta-analysis, which enabled investigation of the effects of the amount of additional treatment offered. Small, statistically significant improvements in activities of daily living (ADLs) and neuromuscular and functional outcomes were found in patients receiving higher intensities of rehabilitation. They found a small but statistically significant intensity-effect relationship.

One of the trials included in both of these meta-analyses was that of Sunderland et al,[4] who conducted a large-scale, randomized trial comparing enhanced physical therapy for the arm with orthodox physiotherapy. They randomly allocated the patients ≈2 weeks after stroke. The enhanced-therapy group was seen twice as often as the orthodox-treatment group. Enhanced treatment consisted of a variety of techniques, including Bobath exercises, biofeedback, microcomputer games, and goal setting. At 6 months after the stroke, the enhanced-therapy group showed a small but statistically significant advantage in recovery of strength, range, and speed of movement and dexterity. Some of the treatment techniques used have been shown in themselves to be effective. Crow et al[19] evaluated biofeedback for arm function and found that patients receiving biofeedback improved more than did an attention placebo control group. However, other techniques used by Sunderland et al[4] have not been evaluated on their own. Therefore, in this and in several others that have found benefits of enhanced treatment for the upper limb,[19–21] both an increased intensity of treatment and a focused or innovative approach to treatment were applied. The aim of the current study was to evaluate the effects of an increased intensity of treatment but not to apply different modalities. The treatment techniques used throughout aimed to reflect current British practice in that they were based on the Bobath approach, the most commonly used approach for stroke patients in Britain,[16] but were augmented by other approaches.

The secondary aim of the study was to determine whether intensive treatment of a type suitable for administration by a physiotherapy assistant was as effective as that provided by an experienced, senior physiotherapist. Bobath treatment is performed by skilled, experienced physiotherapists and is therefore relatively expensive. Recent years have seen a developing role for physiotherapy assistants,[22] partly as a result of pressures to review skill mix in physiotherapy departments.[23,24] In Britain, assistant physiotherapy staff carry out a wide variety of roles and tasks.[25] However, experimental evaluation of their effectiveness is lacking.[26,27]

Subjects and Methods

All stroke patients admitted to Nottingham City Hospital, a large, teaching hospital with acute and rehabilitation facilities, were considered for inclusion in the study. Patients were between 1 and 5 weeks poststroke at entry to the study. They were reviewed weekly and were included if they met the following criteria: (1) were referred to physiotherapy for rehabilitation; (2) had no planned date of discharge from the hospital within the next 7 days; (3) were able to feed themselves and wash their own faces before the stroke; (4) did not have premorbid dementia recorded in the medical notes; (5) were able to speak or understand English before the stroke; (6) had no premorbid severe impairment of the affected upper limb; ie, the patient had functional use of his/her arm before the stroke; (7) were reported by the hospital physiotherapists as being able to tolerate a half-hour session of physiotherapy daily; (8) had some impairment of arm function (see below); and (9) gave consent.

All patients were assessed at entry into the study with respect to the following tests: (1) Rivermead Motor Assessment (RMA)[28] to determine the level of motor impairment and arm function. Those who scored 12 or more on the arm-function scale were excluded because they were not sufficiently impaired. (2) Action Research Arm Test (ARAT)[29] and Ten-Hole Peg Test (THPT)[30,31] to determine the level of arm and hand function in more detail. (3) grip skill, measured by using a dynamometer,[32] to determine grip strength and release. (4) subtests of the Motor Club Assessment[33] to assess motor activity on simple tasks of shoulder shrugging, arm thrusting, and wrist cocking in sitting. (5) Modified Ashworth Scale[34,35] to assess muscle overactivity and its consequences at the elbow and wrist. (6) Ritchie Articular Index[36] and a patient self-rating of pain severity and frequency[37] to assess shoulder pain. (7) Nottingham Sensory Assessment[38] to determine the presence of sensory impairment. (8) Mini Mental State Examination (MMSE)[39] to assess cognitive function. (9) Sheffield Screening Test for Acquired Language Disorders (STALD)[40] to assess language abilities. (10) Rey Figure Copy[41] to assess perceptual impairment. (11) Edinburgh Handedness Inventory (EHI)[42] to determine premorbid handedness for 10 activities. (12) Barthel Index[43] to assess independence in personal self-care.

Patients were randomly allocated to 1 of 3 treatment groups by using computer-generated random numbers in sealed envelopes. The routine-physiotherapy (RPT) group received standard physiotherapy as is given at the City Hospital. This therapy follows predominantly a Bobath approach, and most patients receive treatment each weekday for ≈30 to 45 minutes. RPT patients received no additional treatment by the research physiotherapist.

The qualified-physiotherapist (QPT) group received standard physiotherapy and in addition were treated for ≈2 hours per week by a senior research physiotherapist. This additional treatment consisted of facilitation, specific neuromuscular techniques, and functional rehabilitation, broadly based on the Bobath approach. Patients were encouraged and taught to practice correct movements. When appropriate, instruction was given in motor and functional tasks to be practiced between therapy sessions. The treatment of QPT patients incorporated aspects that are usually administered only by an experienced therapist. These included ongoing assessment and specialized advice at each treatment session, specific facilitatory and inhibitory techniques, and prescription of suitable self-practice activities.

The assistant-physiotherapist (APT) group received standard physiotherapy but in addition were treated for ≈2 hours per week by a physiotherapy assistant. Depending on the patients' impairments, this treatment consisted of instruction in correct positioning and care of the arm; passive, assisted, and active movements; and practice of functional activities. Patients in this group were initially assessed for ≈1 hour by the research physiotherapist. This therapist then super-

vised the assistant's treatment of each patient weekly to update and adjust the treatment program appropriately. The training and assessment of the assistant have been described in detail elsewhere.[26] In brief, the assistant received practical and theoretical teaching at the start of the study, equivalent to 3½ full days of training and evaluation, as well as on-the-job training throughout the course of the study. The physiotherapist compiled a manual of treatment activities to be carried out by the assistant.[44] Activities from this manual were selected to form the treatment program for APT patients. More detailed description of the treatment approach in both APT and RPT groups will be the subject of a future publication.

Patients in the QPT and APT groups received the same amount of additional treatment, ie, 10 hours in total; the difference between them was in the experience and training of the therapist. Patients were treated for 5 weeks. If they were discharged to home during these 5 weeks, treatment continued in the patient's home or on an outpatient basis. For those patients who did not complete >9 hours of additional treatment, the reason for noncompletion was recorded.

Outcome was assessed after 5 weeks of intervention and at 3 and 6 months after stroke by an independent assessor who was unaware of which treatment the patient had received. The primary outcome measures were the RMA arm scale[28] and the ARAT.[29] Outcome was also assessed by the (1) THPT[30,31] to measure dexterity, (2) grip strength (by dynamometer[32]) to measure impairment of grip, (3) RMA gross function scale[28] to assess motor function, (4) Barthel Scale[43] to determine the level of self-care abilities, and (5) Extended ADL Scale[45] to assess independence in instrumental ADLs. At 3 months after stroke, only the RMA arm and gross function scales, Barthel Index, and grip strength were assessed.

The power of the study was calculated on the basis of detecting a difference of 2 points on the RMA arm scale. With $P=0.05$ and a power of 80%, the size of each group would need to be 67 patients. Nonparametric data analysis was used, because the distributions of scores on the outcome measures were significantly skewed and logarithmic transformation did not produce a normal distribution.

A survey of study patients' notes investigated the amount of routine physiotherapy treatment received during the 5-week intervention period. Content analysis of clinical physiotherapy notes was used to estimate the proportion of this routine therapy that was devoted to treatment of the upper limb.

Results

Between May 1, 1995 and October 30, 1997, 1265 stroke patients were admitted to Nottingham City Hospital. Of these, 167 (13%) died before initial assessment, 318 (25%) had a planned discharge date within 7 days, 24 (2%) were unable to feed themselves and wash their own faces before their stroke, 40 (3%) had premorbid dementia, 7 (<1%) were unable to understand English, 7 (<1%) had premorbid impairment of the affected arm, 181 (14%) were unable to tolerate a half-hour session of physiotherapy, and 6 (<1%) refused consent. In addition, 8 (<1%) had previously been recruited for the study, and 43 (3%) were found not to have had a stroke. Of the remaining 464 patients assessed, 182 (14%) had minimal or no arm impairment (RMA arm scale score of 12 or more). Thus, 282 patients were randomly allocated to the 3 groups. Patients were at a median 12 days poststroke at recruitment (interquartile range [IQR], 9 to 17). The biographical characteristics and initial assessment results of patients in the 3 groups are shown in Table 1. There were no significant differences between the groups at initial assessment.

The results of the outcome assessments are shown in Table 2 and are illustrated in Figure 1. In each group, the patients improved on all outcome measures except on the THPT. There were no significant differences between the groups.

TABLE 1. Biographical Characteristics and Initial Assessments

	RPT (n=95)	QPT (n=94)	APT (n=93)	Comparison* *P*
Age				
Median	73	73	73	0.93
IQR	64–80	65–81	66–80	
Sex				
Male	45	51	48	0.63
Female	50	43	45	
Residence				
Alone	33	38	34	0.25
With spouse	57	53	49	
Residential	5	3	10	
Side of weakness				
Right	38	47	40	0.37
Left	57	47	53	
Stroke classification				
TACI	7	9	12	0.25
PACI	29	31	28	
LACI	13	11	17	
POCI	0	0	1	
Uncertain	46	43	45	
MMSE				
Median	21	22	20	0.59
IQR	15–25	4–26	8–26	
Rey				
Median	9	8.5	6.8	0.69
IQR	0–21	0–26	0–21	
STALD				
Median	17	15	15	0.08
IQR	13–19	4–19	6–19	
EHI				
Median	100	100	100	0.90
IQR	90–100	90–100	100–100	
RMA arm				
Median	1	1	1	0.22
IQR	0–4	0–3	0–4	
ARAT				
Median	0	0	0	0.39
IQR	0–4	0–0	0–5	
Barthel				
Median	7	6	6	0.68
IQR	3–9	3–9	4–8	
RMA gross function				
Median	1	1	1	0.33
IQR	1–2	0–2	0–2	
THPT†				
Median	0	0	0	0.68
IQR	0–0	0–0	0–0	
Maximum grip‡				
Median	0	0	0	0.67
IQR	0–17	0–19	0–30	

TACI indicates total anterior cerebral infarction; PACI, partial anterior cerebral infarction; LACI, lacunar cerebral infarction; and POCI, posterior cerebral infarction. MMSE, Mini Mental State Examination (range of possible scores, 0 to 30); Rey, Rey Figure Copy (range, 0 to 36); STALD, Sheffield Screening Test for Acquired Language Disorders (range, 0 to 20); EHI, Edinburgh Handedness Inventory (range, −100 to +100); RMA, Rivermead Motor Assessment (range, arm scale=0 to 15; gross function scale=0 to 13); ARAT, Action Research Arm Test (range, 0 to 57); Barthel, Barthel Activities of Daily Living Index (range, 0 to 20); THPT, Ten-Hole Peg Test (range, −100 to +100).

*Comparisons were carried out using a Kruskal-Wallis 1-way ANOVA for ordinal data and χ^2 test for categorical data.

†THPT reported as percentage ability of affected arm compared with unaffected arm.

‡Maximum grip reported as percentage maximum grip with affected hand compared with maximum grip with unaffected hand.

TABLE 2. Comparison of Outcome of Patients

	Postintervenion			Comparison*	3 Months			Comparison*	6 Months			Comparison*
	RPT	QPT	APT	*P*	RPT	QPT	APT	*P*	RPT	QPT	APT	*P*
RMA arm												
Median	4	3	3	0.73	5	3	4	0.65	6	4	6	0.69
IQR	1–8	0–8	1–9		1–8	0–8	1–9		1–9	0–9	1–10	
ARAT												
Median	5	1	1	0.62					19	3	23	0.55
IQR	0–38	0–35	0–45						0–45	0–39	0–47	
Barthel												
Median	13	12	12	0.66	14	14	14	0.51	16	16	16	0.65
IQR	7–17	8–16	7–17		10–19	7–17	10–17		12–19	9–18	12–18	
EADL												
Median	7.5	5	6	0.31					13	15	14	0.65
IQR	3–26	2–13	4–14						7–33	5–28	6–33	
RMA gross function												
Median	5	3	2	0.80	6	5	6	0.59	7	6	7	0.61
IQR	1–8	1–7	1–8		1–9	1–8	1.5–9		4–9	1–9	2–9	
THPT†												
Median	0	0	0	0.53					0	0	0	0.75
IQR	0–56	0–26	0–45						0–63	0–55	0–62	
Maximum grip‡												
Median	11	0	6	0.46	19	9	2	0.29	25	23	24	0.88
IQR	0–49	0–34	0–52		0–58	0–38	0–54		0–61	0–55	0–61	
Lost to follow-up, n	2	2	2		2	2	7		3	3	6	
Deceased, n	3	5	9		9	8	12		11	10	17	

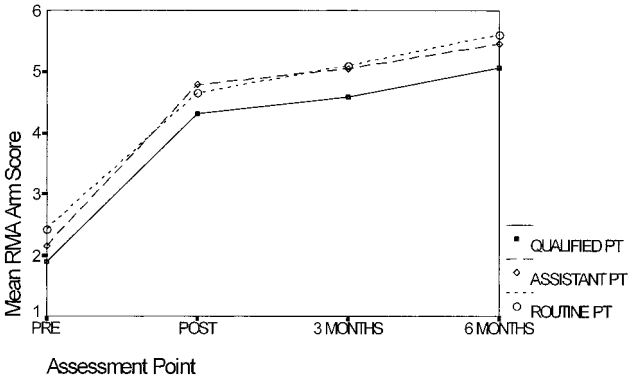
EADL indicates Extended Activities of Daily Living Assessment (range, 0 to 66). For other abbreviations, see the footnote to Table 1. Patients who were lost to follow-up or who died during the study were not included in the outcome analysis.

*Comparisons were carried out using a Kruskal-Wallis 1-way ANOVA for ordinal data and χ^2 test for categorical data.

†THPT reported as percentage ability of affected arm compared with unaffected arm.

‡Maximum grip reported as percentage maximum grip with affected hand compared with maximum grip with unaffected hand.

The amount of treatment given to patients is summarized in Table 3. All distributions were significantly skewed; therefore, medians and IQRs are presented. Patients in the QPT and APT groups received equivalent amounts of therapy ($P=0.27$) and an equivalent number of treatment sessions ($P=0.85$, Mann-Whitney *U* tests). The proportion of patients completing the additional treatment was 56% of QPT patients and 46% of APT patients. This difference between the groups was not statistically significant ($P=0.17$). The most common reason for noncompletion was inability to tolerate the amount of extra treatment, affecting 20% of QPT patients and 14% of APT patients. The second most common reason was recovery to minimal arm impairment during the intervention period, which accounted for 10% of QPT patients and 13% of APT patients.



RMA arm scale mean score at each assessment point.

The numbers of patients in each group who deteriorated in their RMA arm scale score are given in Table 4. These data are presented to compare the findings with a meta-analysis of studies of physiotherapy[17] that found a statistically significant effect of intensity of therapy on the combined outcome of death or deterioration at the end of follow-up. Table 4 shows that at 6 months, the numbers in each group with the combined outcome of deterioration on the RMA arm scale or death were 19 (18%) of RPT, 16 (15%) of QPT, and 23 (21%) of APT patients. These proportions were not statistically significantly different ($\chi^2=1.33$, $P=0.51$).

The survey of patients' clinical physiotherapy records showed that they received a median of 1040 minutes of routine inpatient physiotherapy during the intervention period. Content analysis of the records showed that specific treatment of the upper limb was recorded on 28% of treatment days.

TABLE 3. Summary of Additional Treatment Given

	QPT (n=94)	APT (n=93)	Comparison* P
Minutes of treatment by "primary" therapist			
Median	575	430	0.27
IQR	281–600	235–600	
Minutes of supervision of the assistant by the physiotherapist			
Median	0	120	
IQR	0	85–158	
Number of sessions			
Median	11	11	0.85
IQR	7–13	6–14	
Number (%) who received >9 hours of treatment	53 (56)	43 (46)	0.17
Reasons for receiving <9 hours of treatment, (%)			
Recovered (RMA arm test <11)	9 (10)	12 (13)	
Chose to withdraw	3 (3)	8 (9)	
Transferred to different hospital	0	2 (2)	
Considered unsuitable for assistant	0	1 (1)	
Change in diagnosis	1 (1)	5 (5)	
Died during intervention illness or low tolerance of treatment	19 (20)	13 (14)	
Lack of staff resources (holidays, etc)	4 (4)	5 (5)	
Total receiving <9 hours of treatment	41 (44)	50 (54)	

*Comparisons were carried out using the Mann-Whitney *U* test for ordinal data and χ^2 test for categorical data.

Discussion

All patients in the study improved in their gross motor function, independence in self-care, instrumental ADL ability, and upper-limb motor and functional abilities. However, 10 hours of additional physiotherapy for the upper limb with use of the current typical British approach showed no detectable benefit in acute stroke patients in their upper-limb motor function or ADL ability. In contrast, a number of other evaluations of interventions aimed at improving motor recovery of the arm after stroke have reported benefit.[4,5,19,21,46–48] This suggests that the type of therapy applied and the selection of patients to whom it is applied are important. In considering our findings and their implications, a number of factors should be taken into account. These include the heterogeneity of the group studied, the severe level of impairment of the majority of the patients, and their tolerance of the additional treatment. Further considerations are the measures used to assess outcome and the amount of additional therapy that was provided.

This study aimed to recruit all patients admitted to the hospital after stroke who were receiving physiotherapy treatment. This design resulted in a heterogeneous group in which many patients were severely affected at the time of admission to the study. In terms of upper-limb impairment, only 34% scored >1 on the RMA arm scale, only 10% had sufficient dexterity to perform the THPT, and only 20% scored >9 on the ARAT, indicating some ability to grip or grasp objects.

In comparison with other large randomized, controlled trials of upper-limb treatment by Sunderland et al[4] and Feys et al[5] that have reported beneficial effects, our patients were older and more impaired on the Barthel Index at randomization. In the study of Feys et al, patients had to be able to sit independently and perform the experimental treatment independently for 30 minutes. Because the admission criteria for our study were less restrictive, more severely impaired patients were included. These factors meant that our patients were less likely to tolerate the increased amount of treatment, but they represent patients to whom, were additional physiotherapy available, it would be offered.

On the other hand, it might be argued that in routine clinical practice, if additional treatment time were available, it could be more selectively directed towards patients who had the tolerance to participate in it, and this selection might increase the efficiency of treatment. In the study, about half of the QPT and APT patients (n=91) did not complete 10 hours of additional treatment. For 32 of these patients, this noncompletion occurred because of low tolerance to physical rehabilitation, but for the other 59, a variety of reasons led to

TABLE 4. Proportion of Patients Who Deteriorated on the RMA Arm Scale or Who Died

	Postintervention			6 Months		
	RPT (n=95)	QPT (n=94)	APT (n=93)	RPT (n=95)	QPT (n=94)	APT (n=93)
Worse (difference between initial and 6-month RMA arm score <0)						
No.	11	3	3	7	5	4
%	10	3	3	7	5	4
Deceased						
No.	3	5	10	12	11	18
%	3	5	9	11	10	17
Combined outcome: worse/deceased						
No.	14	9	13	19	16	23
%	13	8	12	18	15	21

noncompletion. This means that it would be difficult in practice to accurately predict which patients would complete treatment.

Outcome was assessed mainly on functional measures because it was considered that these would be the most important indicators of benefit for patients. However, outcome measures that have produced more evidence for the benefits of stroke physiotherapy have been mainly impairment measures.[12,18]

Our findings did not confirm those of recent meta-analyses that have suggested that more intensive therapy improves outcome in terms of impairment, function, and disability,[18] nor did they confirm the findings of Langhorne et al[17] of a significant reduction in deterioration or death by the end of follow-up. There are several possible explanations for this result. The rationale for meta-analyses is that the modest effect sizes commonly found in rehabilitation studies imply that sample sizes need to be very large to produce statistically significant results[15] ; thus, our sample size may have been insufficient to detect small but significant treatment effects between the groups. It has been suggested that the greater the contrast between the routine and additional levels of treatment, the greater the effects.[18] The additional treatment that we gave represented an average increase of 58% of the patients' routine amount of physiotherapy.[46] Two hours per week of additional treatment, over and above the typical 3 to 4 hours per week of physiotherapy, was chosen as feasible within current health service provisions and is comparable to the proportional increases in therapy given in other intensity studies.[17,18] On the other hand, it could be argued that a relatively low intensity such as this may be insufficient to influence outcome.

Other studies of upper-limb treatments[4,5,19,20] have found differential effects of therapy between severely and less severely impaired patients. Feys et al[5] evaluated the effects of a repetitive, structured treatment that involved use of the splinted, affected arm to rock a rocking chair in which the patient was sitting. Greatest benefits were found in more severely arm-impaired patients. These effects were confined to motor outcome on the Brunnstrom-Fugl-Meyer assessment and did not generalize to arm function, as measured by the ARAT, nor to ADL, as measured with the Barthel Index. Crow et al[19] found transient benefits of electromyographic biofeedback treatment of the arm, although the effects were confined to severely disabled patients. Other studies that have included both severely and less severely arm-impaired patients have found effects in less severely impaired patients only.[4,20] Many other studies finding benefit have included only patients who have some motor recovery and usually some hand movement.[21,46,48] Therefore, it may be that our analysis of the group as a whole conceals differential benefits in subgroups of patients. There were no statistically significant differences between the groups at randomization. However, the intervention groups, in particular the QPT group, contained a higher proportion of severely impaired patients. This may have reduced the likelihood of observing benefits of treatment if the treatment given was particularly appropriate for less disabled patients. Further analysis of whether any subgroups of patients benefited from the additional treatment will be performed.

The treatment administered to patients aimed to reflect that used by most British physiotherapists. Many studies that have reported benefits of upper-limb treatment have evaluated innovative programs derived from theoretical models of motor learning,[4,20,46] animal studies of skill acquisition,[47,48] and recognition of the importance of feedback on motor performance.[19,21] Other studies have used repetitive activities.[5,46,49] Targeted interventions based on theoretical understanding of motor learning and muscle activity have been found to be effective when applied to selected patients with less severe arm impairment. For patients with more severe arm impairment, repetitive stimulation of the arm has been found to result in sustained motor gains,[5] although these have not generalized to function. Our more general treatment approach, applied to a heterogeneous group of stroke patients, did not show the benefits reported by other studies. This would seem to confirm criticisms of current traditional approaches expressed by a number of reviewers[12,50,51] and support the view of Wagenaar and Meijer[12] that "A better theoretical understanding of deficits in motor co-ordination and perception may turn out to be a prerequisite for designing new and more effective rehabilitation methods." Future research will need to continue to seek an integration of clinical practice with experimental findings concerning motor learning and muscle activity. A further concern is that the strongest evidence of the effects of physiotherapy for stroke has been in measures of impairment. The extent to which motor improvements can be translated into functional abilities and the best methods of encouraging such translation are therefore in need of investigation.

In this study, only 1 qualified and 1 assistant physiotherapist administered the research therapy, so it is possible that the results could have been specific to these individuals. The study compared patients receiving usual amounts of physiotherapy with patients receiving additional therapy. Therefore, our findings cannot provide information concerning the differences between patients receiving some physiotherapy and patients receiving no physiotherapy, nor can they answer questions concerning the effectiveness of more intensive physiotherapy aimed at other problems, for instance, mobility or balance. Findings are also limited to the effectiveness of additional physiotherapy based on the current usual British approach. Therefore, it cannot be concluded that physiotherapy for the upper limb is not effective, only that additional physiotherapy of $\approx$2 hours per week following the current British approach does not benefit a heterogeneous population of patients admitted for rehabilitation after their stroke.

In the present study, additional physiotherapy was given to stroke patients with arm impairments by using a physiotherapy approach that aimed to reflect current British practice. The group comparisons showed no significant benefits of additional physiotherapy whether this was given by an assistant or a qualified physiotherapist. Patients in both control and intervention groups improved in terms of ADLs and arm function. Consideration of our findings in the light of previous studies that have shown benefits indicate that further specific investigations are required to elucidate the influence

of content and amount of therapy for the arm and the selection of patients to whom it is given.

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