Controlled randomised crossover trial of the effects of physiotherapy on mobility in chronic multiple sclerosis

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Abstract

***Objectives*—To determine whether physiotherapy can improve mobility in chronic multiple sclerosis and whether there is a difference between treatment at home and as a hospital outpatient?**

***Methods*—A randomised controlled crossover trial was undertaken in patients with chronic multiple sclerosis who had difficulty walking and were referred from neurology clinics: allocation was to one of six permutations of three 8 week treatment periods separated by 8 week intervals: treatments consisted of physiotherapy at home, as an outpatient, or "no therapy". The main outcome measures were based on independent assessments at home and included mobility related disability (primary outcome: the Rivermead mobility index), gait impairments, arm function, mood, and subjective patient and carer ratings. Therapy was assessed by recording delivery, achievement of set targets, patient and carer preference, and cost.**

***Results*—On the Rivermead mobility index (scale 0–15) (primary outcome) there was a highly significant ($p<0.001$) treatment effect of 1.4–1.5 units favouring hospital or home based therapy over no therapy: this was supported by other measures of mobility, gait, balance, and the assessor's global "mobility change" score: there was no major difference between home and hospital. Carers preferred home treatment but neither they nor patients discerned greater benefit there. Estimated costs of home physiotherapy were £25/session and those at hospital were £18 (including £7 patient travel costs).**

***Conclusion*—A course of physiotherapy is associated with improved mobility, subjective wellbeing, and improved mood in chronic multiple sclerosis compared with no treatment but benefit may only last a few weeks: there is little to choose between home and hospital based therapy but the first is more costly, mainly due to skilled staff travelling time.**

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Difficulty in walking is very common for patients with multiple sclerosis. Of 301 prevalent cases in South Glamorgan[1] 220 (73%) could not walk or had an abnormal gait. Potentially many patients might gain from physiotherapy if it were effective[2–4] but evidence for benefit in controlled studies is slight and conflicting.[5–8] A trial of inpatient physiotherapy in chronic multiple sclerosis[5] showed no statistically significant differences between treated and untreated groups and we decided to test whether physiotherapy might be more efficacious if administered at home or as an outpatient.

Methods

SETTING AND PATIENTS

Patients with definite or probable multiple sclerosis[9] who complained of difficulties with walking were recruited from neurology clinics at the University Hospital of Wales: each was telephoned, the study discussed using a screening proforma, and a written information sheet sent. Patients were required to be at least 18 years old, be able to walk 5 metres with or without a mechanical aid, not to be in a current relapse of multiple sclerosis, and to be free from other major general medical or surgical disorders or pregnancy: they needed to attend the rehabilitation hospital twice a week for 8 weeks using private transport (costs paid by the study), and to agree to therapy in their home twice a week for 8 weeks, and assessments at home.

PROTOCOL

The trial protocol was approved by the local research ethics committee and all patients gave written consent. Each patient received three 8 week periods of treatment consisting of "home physiotherapy", "hospital outpatient physiotherapy", and "no physiotherapy". Treatment periods were separated by 8 weeks; the treatment order was by random allocation to one of the six possible permutations (in the Department of Computing and Statistics via sealed envelopes given to treating physiotherapists). This balanced design was intended to eliminate confounding of treatment with subjects or periods and to balance for possible carry over effects. Assessments were carried out in the week before and the week after each treatment period and 8 weeks after the final period.

Table 1 Data collected by assessor each visit

Disability measures:
- Rivermead mobility index[10]
- Barthel activities of daily living index[11]
- Frenchay activities index[12]
- Nottingham extended ADL (mobility element)[13]

Balance:
- Functional ambulation category[14]
- Balance score,[15] ability and time to balance on either leg

Walking and upper limb function:
- Time and number of paces for two standard 6 m walks (with one turn)
- Nine hole peg test[16]
- Assessor's global view of "mobility change" (visual analogue score)
- Video recording of gait (to be submitted subsequently)

Cognition and affective state:
- Short orientation-memory-concentration test[17]
- Hospital anxiety and depression scale[18]

Visual analogue scales (patient and carer):
- Mobility related competence: patient and carer
- Mobility related distress (concern): patient and carer
- Falls: carer concern

TREATMENT

Patients received physiotherapy for two sessions of 45 minutes each week on different days for 8 weeks, either at home or in the Physiotherapy Department from two experienced (senior 1) neurophysiotherapists (SS, JF-D) funded half time by the study grant. Each treated the same patient for both active periods and was blinded to the assessor's procedures and findings. The principles of physiotherapy applied at home and hospital, although similar in some respects, differed on account of space and equipment considerations in the home (appendix): they involved an individualised problem solving approach, focusing more on specific functional activities at home and more on specific facilitation techniques in hospital. Physiotherapists recorded therapy time, time for other patient related tasks, and journey times. After each treatment period they used a visual analogue scale to assess to what extent up to four therapy objectives had been achieved.

ASSESSMENTS

Assessments (table 1) were made in the patients' home by KJF, a senior physiotherapist based at another hospital, unaware of treatment allocation, and who did not discuss patients with the treating physiotherapists or treatment with patients.[19] Assessments included the primary outcome measure (Rivermead mobility index: see below) and a range of secondary measures to estimate any effect on general disability, or specific impairments or activities including balance, walking, arm function, cognition, and mood. Patients and their carers were also asked their opinion about effects on mobility competence, distress related to mobility issues, and falls.

STATISTICAL METHODS

The primary outcome measure of efficacy was a comparison of the changes in the Rivermead mobility index on one treatment to those occurring on another treatment. It was assumed (based on the previous trial[5]) that within subject changes would have an SD of 2 units: it was then estimated that using 42 patients there would be 90% power to detect a clinically relevant 1 unit difference at the $\alpha = 0.05$ level. The main outcome measures were analysed using a three way analysis of covariance (ANCOVA) model appropriate to the crossover design, with subject, period (first, second, or third), and treatment (home physiotherapy, hospital physiotherapy, or none) as factors, and the corresponding baseline value at the start of the relevant period as covariate. Differences between each pair of treatments were estimated, together with 95% confidence intervals (95% CIs). As the fit of a gaussian model was in some instances far from ideal, confirmatory non-parametric analyses were performed, using the Friedman two way rank analysis of variance (ANOVA) method with subject and treatment as factors, without adjustment for baseline. Visual analogue scores representing changes from the previous period were analysed by a corresponding three way ANOVA model, with no covariate. Preference data in table 2 was analysed using the paired (McNemar) χ^2 test; confidence intervals for the degree of preference for home compared to hospital physiotherapy were calculated.[20] The degree of achievement of four targets, as rated by the treating therapist (table 3), was compared between home and hospital physiotherapy by the Wilcoxon matched pairs signed ranks test.

Results

Of 45 patients referred 42 were recruited and entered the study in just over a year (table 4). One patient declined further assessments after a single treatment period, another after recruit-

Table 2 Patient, carer, and treating physiotherapist preferences for home or hospital physiotherapy

	Responses	*Home better*	*Hosp better*	*Either**	*Neither†*	*Home advantage‡*	*95% CI*	*McNemar X^2*	*p Value*
Patient:									
Benefit	40	13	14	12	1	−0.025	−0.267 +0.221	0.04	0.85
Preference	40	17	12	10	1	+0.125	−0.135 +0.366	0.86	0.35
Carer:									
Benefit	38	14	12	10	2	+0.053	−0.202 +0.299	0.15	0.69
Preference	38	17	4	16	1	+0.342	+0.116 +0.526	8.05	0.005
Physiotherapist:									
Benefit	40	11	5	20	4	+0.150	−0.049 +0.334	2.25	0.13

* Either=equal benefit in either situation.
† Neither=no benefit in either.
‡ Estimated advantage of home compared to hospital in first line is (13-14)/40=−0.025 (thus negative sign=home slightly less good than hospital for this outcome).

Table 3 Therapy delivery

40 Patients	*Home*			*Hospital*		
Missed therapy sessions	10/640 (1.6%)			37/640 (5.8%)		
	Mean	*SD*	*Range*	*Mean*	*SD*	*Range*
Period of visits (days)	59	7	29–72	55	11	1–66
Total therapy (h)	11.8	0.7	8.3–12.0	11.3	2.1	0.8–12.0
Duration of treatment (min)	45	0	45–45	45	0.3	43–45
Total extra time (h)	3.0	0.8	1.9–4.4	3.2	1.1	1.2–7.1
Average extra (mins)	11	3	7–17	13	5	6–35
Travel time to patient (h)	11	5	7–17	—	—	—

Therapist rating scores for achievement of four target outcomes (visual analogue scale 0–100)

	Home		*Hospital*		*Wilcoxon paired test p value*
Outcome 1	66	33	62	32	0.30
Outcome 2	62	28	60	30	0.89
Outcome 3	64	31	62	31	0.76
Outcome 4	66	35	62	33	0.54

Table 4 Patient characteristics (n=42)

Age (mean (range) y)	47.2 (28.2–68.8)			
Sex	15 men, 27 women			
Onset of symptoms to diagnosis (mean (SD) y)	4.4 (4.6)			
Duration of symptoms of MS at study entry (mean (SD) y)	12.3 (8.4)			
Time since last relapse to study entry in patients with relapses (median (range) y (rounded to nearest y))	1 (0–21)			
Expanded disability status scale[26] score (0–10), n (41 assessed)	4.0	2	4.5	2
	5.0	1	5.5	2
	6.0	17	6.5	17
Distance from hospital (mean (SD) (range) miles)	9.8 (7.4) (1.0–26.0)			
Journey time to hospital (mean (SD) (range) min)	25 (10) (10–50)			

ment but before treatment; thus 40 patients formed the basis of the analysis, of whom 39 underwent all assessments. Slightly more treatments were missed in hospital than at home (table 3). Total therapy delivered at home was slightly greater than in hospital but time for other tasks was slightly higher in hospital; achievement of treatment targets was similar at home and hospital. The assessor was aware of being unmasked to active treatment (but not venue) in 28 instances of 283 home visits.

The results in tables 5 and 6 refer to an analysis of all 40 patients treated and assessed: the results shown include the primary outcome measure and a selection of secondary outcome measures shown in table 1 (other data analysed similarly (except video data) are available on request from the authors but did not change the essential outcome of the study). For the post-treatment Rivermead mobility index (primary outcome) ANCOVA showed that there was a highly significant difference ($p<0.001$) between the three treatments but no clear evidence of any difference between the three periods ($p=0.216$). There was significant variation between the patient's response on this measure but no significant effect of the pretreatment score. Pretreatment scores and differences in post-treatment scores after adjustment for patient, period, and baseline are shown in tables 5 and 6. Thus for the Rivermead scale the advantage of hospital over no treatment was a mean of 1.4 units (95% CI 0.6 to 2.1) and was similar for home compared with no treatment so the null hypothesis of no difference was clearly rejected ($p<0.001$): there was no significant difference between home and hospital treatment. Estimates of differences in treatment effect by period hinted at a reduced effect in period 3 but this was not significant.

Findings on the Rivermead index were essentially corroborated by other measures. Less significant findings on the Barthel index

Table 5 Disability, balance, walking, upper limb, and global impression of mobility (assessor). Scores before and after treatment (mean (SD)): effect sizes by treatment: n=40 patients*

	Treatment					
Scale	*None*		*Hospital*		*Home*	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
Rivermead mobility index (0–15)	10.0 (3.7)	9.1 (3.9)	10.0 (3.6)	10.5 (3.5)	9.6 (3.2)	10.6 (2.9)
	Effect size	*Estimate*	*95% CI*		*p Value*	
	Hospital-none	1.4	0.62 to 2.14		<0.001	
	Home-none	1.5	0.73 to 2.26		<0.001	
	Home-hospital	0.1	−0.65 to 0.87		0.77	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
Balance time (s)	17.7 (13.7)	15.0 (13.8)	18.1 (13.3)	19.9 (13.2)	15.0 (13.4)	19.7 (13.2)
	Effect size	*Estimate*	*95% CI*		*p Value*	
	Hospital-none	4.82	1.57 to 8.07		0.004	
	Home-none	5.49	2.19 to 8.80		0.001	
	Home-hospital	0.68	−2.64 to 3.99		0.69	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
Walk A (s)	143 (117)	148 (129)	151 (125)	138 (108)	145 (115)	138 (110)
	Effect size	*Estimate*	*95% CI*		*p Value*	
	Hospital-none	−14	−23 to −5		0.003	
	Home-none	−14	−23 to −6		0.002	
	Home-hospital	0	−9 to 8		0.94	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
Nine hole peg (s)	194 (67)	207 (85)	199 (86)	190 (69)	201 (76)	194 (70)
	Effect size	*Estimate*	*95% CI*		*p Value*	
	Hospital-none	−18	−32 to −4		0.014	
	Home-none	−13	−27 to 1		0.076	
	Home-hospital	5	−9 to 19		0.48	
	Post	*FU*	*Post*	*FU*	*Post*	*FU*
Assessor global† mobility change scale (0–100: 50=no change)	42 (11)	46 (11)	62 (17)	44 (11)	65 (17)	44 (14)
	Diff post-treatment score	*Estimate*	*95% CI*		*p Value*	
	Hospital-none	19.8	14.0 to 25.7		<0.001	
	Home-none	22.4	16.6 to 28.3		<0.001	
	Home-hospital	2.6	−3.2 to 8.4		0.38	

*The results for all other scales used in the study are available from the authors in similar format.
†For this scale "Post" refers to the assessment immediately after treatment period: "FU" (follow up) refers to that undertaken 6–7 weeks later during which no treatment was given.

Table 6 Mood and patient/carer visual analogue scales. Scores before and after treatment (mean SD): effect sizes by treatment: n=40 patients*

Scale	*Treatment*					
	None		*Hospital*		*Home*	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
HADS-anxiety (0–21)	6.5 (4.9)	8.0 (5.3)	6.7 (5.2)	6.4 (4.4)	7.3 (4.9)	6.6 (4.5)
	Effect size	*Estimate*	*95% CI*		*p Value*	
	Hospital-none	−1.48	−2.44 to −0.51		0.003	
	Home-none	−1.24	−2.23 to −0.26		0.014	
	Home-hospital	0.23	−0.74 to 1.20		0.64	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
HADS-depression (0–21)	6.5 (4.2)	7.6 (4.7)	6.5 (3.9)	5.4 (2.8)	6.6 (4.5)	5.9 (3.9)
	Effect size	*Estimate*	*95% CI*		*p Value*	
	Hospital-none	−2.22	−3.25 to −1.18		<0.001	
	Home-none	−1.70	−2.73 to −0.66		0.002	
	Home-hospital	0.52	−0.51 to 1.55		0.32	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
VAS-patient mobility (0–100)	42 (21)	35 (20)	41 (21)	60 (22)	38 (17)	59 (18)
	Effect size	*Estimate*	*95% CI*		*p Value*	
	Hospital-none	25.2	18.3 to 32.0		<0.001	
	Home-none	24.2	17.3 to 31.0		<0.001	
	Home-hospital	−1.0	−7.8 to 5.8		0.77	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
VAS-carer mobility (0–100)	43 13	37 (21)	43 (20)	51 (19)	41 (19)	52 (23)
	Effect size	*Estimate*	*95% CI*		*p Value*	
	Hospital-none	16.0	6.7 to 25.3		0.001	
	Home-none	17.6	8.1 to 27.1		<0.001	
	Home-hospital	1.6	−7.6 to 10.8		0.73	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
VAS-falls (0–100)	49 (18)	42 (16)	44 (18)	60 (20)	48 (20)	61 (21)
	Effect size	*Estimate*	*95% CI*		*p Value*	
	Hospital-none	18.3	9.0 to 27.6		<0.001	
	Home-none	20.7	11.2 to 30.2		<0.001	
	Home-hospital	2.4	−6.8 to 11.5		0.62	

*Results for all other scales used in the study are available from the authors in similar format.

probably reflected a ceiling effect with scores clustered at the upper end of the scale. Balance score and time improved with active treatment as did measures of walking. The short test of concentration, orientation, and memory was not influenced by treatment but anxiety and depression scores improved after home and hospital treatment.

The assessor's global view of "mobility change" used a visual analogue scale where 50 represented no change from the previous assessment, 100 maximum improvement, and 0 maximum deterioration. Effect sizes for each treatment period are shown in table 5. Post-treatment values (visits 2, 4, 6) were all over 50 on average for the active treatment periods but not for controls whereas the follow up scores (visits 3, 5, 7) showed a falling away of benefit in the two active treatment groups to levels no different from the control group. Patients perceived better mobility and a reduced tendency to fall after both active treatments and this was confirmed by their carers (table 6). Patients slightly preferred home treatment; carers assessed benefit as slightly greater at home but had a strong preference for home treatment. Physiotherapists judged that home treatment was more often beneficial than hospital treatment, but that in about half the patients venue made no difference to benefit, and that about 10% showed no benefit in either (table 2).

Costs of a therapy session were calculated from the employment costs of the physiotherapists, duration of sessions including extra time (table 3), travel time, and mileage costs. On average a home therapy session cost £25 whereas a hospital session cost £11: the second excludes patient travel costs, which were estimated as £7 per visit, and time.

Discussion

This randomised crossover study of the effects of physiotherapy in multiple sclerosis has, unlike our previous inpatient study, clearly shown that mobility can be improved to a clinically relevant extent as assessed at home by an independent observer. There was no substantial difference between the benefits of therapy delivered in the patient's home or as a hospital outpatient although carers preferred home treatment. Improvement amounted to an average of 1.4–1.5 units on the primary outcome criterion, the Rivermead mobility index; more than the minimum clinically relevant improvement used for the study power calculation. The Rivermead index has not been widely used in multiple sclerosis but has been found valid and sensitive to changes and functional gains in a rehabilitation setting over time, as well as being rapid and simple to use in the patient's environment.[21 22] Improvements found with the Rivermead index are supported by changes in other disability scales, measures of impairment, and subjective views of patients, carers, and assessor. There is an impression that net benefit results, in part, from prevention of deterioration in "no treatment" periods (tables 5 and 6). As the physiotherapy approaches differed to some extent at home and in hospital we cannot state whether venue or approach, both, or neither are relevant factors in the benefit shown. A study constraining the therapy approaches to be identical in these different

environments would be difficult to construct although different approaches in the same environment can be tested (see below).[7]

The present study was not designed to test a general multidisciplinary rehabilitation package but to investigate the effect of physiotherapy on ambulation—although physiotherapists offered general advice and made referrals to various agencies when appropriate (not differing significantly between home and hospital venues), their therapy role was specifically directed to predetermined targets based on their own initial assessments of mobility. A study of "physical rehabilitation" for 3 weeks as an inpatient was shown to have a benefit on the motor domain of the functional independence measure and the mental (but not physical) component of health related quality of life profile which persisted (though fading) 6 weeks later.[8] A general inpatient rehabilitation package was shown in a randomised controlled trial[23] to benefit patients and a follow up study of such a package, on more disabled patients with multiple sclerosis (preassessed as "suitable" for inpatient rehabilitation) assessed openly without a control group in later assessments, supports the view that benefits may carry over into the community although they decline with time[24]: however, the component of improvement related to walking is not clear. The findings contrast with the previously reported inpatient physiotherapy trial[5] in which assessments undertaken in the patients' home failed to show a statistically significant benefit. We suspect that the greater duration of therapy in the present study and the reduced level of necessary activity while a hospital inpatient in the previous study may have been important factors in this difference. Therapy (outpatient or home) may also have been more focused on activities relevant to the patient and the home environment in the present study compared with the inpatient study.

We cannot state what "dose" of treatment was necessary: optimum number, duration and interval of treatment sessions all need further study but affect cost and practicality. Furthermore, the specific content of physiotherapy might be important although a pilot study showed no difference in benefit between task oriented (disability focused) and facilitation (impairment based) approaches.[7] The tendency of benefit from active treatment to wane during follow up with little carry over from one treatment period to the next suggests a short lived effect, unlikely to result in long term benefit unless repeated, continuous, or supported by other interventions or change in motor behaviour. If major benefit from general education and advice given by a physiotherapist carried through from one period to the next a positive period effect and less falling away of perceived benefit by the assessing therapist across follow up periods might be anticipated (before next treatment session) but neither were seen. These findings also support our supposition that a crossover study can be utilised for evaluation of short term therapy interventions in multiple sclerosis.

Benefits found might result from specific factors (for example, change in posture or tone) or secondary factors such as altered mood, effects (on motivation and confidence) of increased exercise,[6] or discussions about mobility. Upper limb function improved as well as mobility. Several therapy techniques (appendix) were directed at improved trunk control and head, neck, and trunk posture so potentially influencing arm function. We tested the effect of pretreatment mood on the Rivermead mobility index by examining treatment effect against dichotomised (<8, $\geqslant 8$) mood scores and examining the rank correlation (Spearman) of change in Rivermead score against pretreatment anxiety or depression subscore. Hospital treatment data suggested a tendency (non-significant) for greater benefit in those who were initially depressed but this was less evident for home treatment. Benefit from home treatment was, if anything, less marked in those who were anxious. Further studies could target issues of specific versus non-specific treatment, of mood enhancement on mobility, and the neuropsychological characteristics of patients expected to benefit.

Home based therapy was more costly to the health service in our simple analysis due to the substantial time spent travelling by the physiotherapist. This element could be reduced by utilising more locally based therapists but they may have less specific expertise in multiple sclerosis. It should also be emphasised that, in this study of efficacy, outpatient physiotherapy was optimally arranged using private transport or taxi and avoiding hospital transport systems which are a potential source of both missed appointments or late arrival for therapy and hence increased cost.

We conclude that, compared with no treatment, an 8 week course of physiotherapy (twice a week) results in significant improvements in mobility, subjective wellbeing, and mood in patients with chronic multiple sclerosis whether it is provided at home or in a hospital outpatient physiotherapy department (the second being associated with less direct cost to the NHS). These benefits, although clinically significant and relatively low in cost, are short-lived, suggesting that ongoing physiotherapy input might be necessary for sustained benefit whether this is defined as improvement in mobility or prevention of deterioration.

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Appendix

TECHNIQUES USED BY TREATING THERAPISTS [27]

- Goal setting with individual patient
- Trunk mobilisation: to improve midline orientation, to increase pelvic mobility, to access volitional activity, to increase trunk stability thereby freeing upper 1imbs for function, to increase proximal stability and free lower limbs to step
- Facilitation of increased pelvic control—in supine, sitting, and standing, or modifications of these postural sets
- Facilitation, through handling, of alteration in tone, either increased or decreased.

- Facilitation of movement into and out of different postural sets
- Facilitation of normal movement in trunk, limbs, and head and neck
- Facilitation of proprioceptive or sensory input
- Mobilisation of shortened soft tissues—by therapist, patient, carer
- Stretches by therapist, patient, carer—to maintain or regain length in musculature
- Analysis and re-education of gait, including provision of appropriate aids
- Establishment of home exercise programme, during either treatment block
- Advice on—seating, wheelchair, bathing, posture, exercise, continence
- Referral to other appropriate professionals—for example, orthotist, occupational therapist, continence advisor
- Specific functional activities—bed mobility, eating and drinking, access problems at home, stairs, steps, uneven ground
- Provision of information about multiple sclerosis, including contact telephone numbers for relevant agencies.

HOME APPROACH

- Looking more at specific functional activities and problems—stairs, bath access, bed mobility, seating, access to house and car, visiting local shops, parks, and facilities
- Restrictions of space and lack of equipment available
- Interference of social activities during treatment—adapting to these and using as part of treatment session, if appropriate
- Patients more likely to identify objectives related to their home environment.

HOSPITAL APPROACH

- More treatment time spent on specific facilitation techniques
- Therapist more likely to lead setting of objectives
- Availability of colleagues' opinions and support if needed
- Treatment sessions more focused (fewer distractions)
- Availability of adjustable height, firm surface (Bobath plinth) increases specificity of treatment techniques.

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