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REVIEW ARTICLE

PHYSIOTHERAPY BASED ON THE BOBATH CONCEPT FOR ADULTS WITH POST-STROKE HEMIPLEGIA: A REVIEW OF EFFECTIVENESS STUDIES

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The Bobath concept, also known as neurodevelopmental treatment, is a widely used approach in the rehabilitation of hemiparetic subjects in many countries. Despite 50 years of clinical use its effectiveness is questionable. This paper aims to examine whether there is evidence to accept neurodevelopmental treatment as an effective approach. A systematic literature search was undertaken. Fifteen trials have been selected and classified according to a 5-level hierarchic scale of evidence for clinical interventions. Results show no evidence proving the effectiveness of neurodevelopmental treatment or supporting neurodevelopmental treatment as the optimal type of treatment, but neither do methodological limitations allow for conclusions of non-efficacy. Methodological aspects of selected studies are discussed and requirements for further research are suggested.

Key words: Bobath concept, stroke, hemiplegia, rehabilitation.

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INTRODUCTION

Motor rehabilitation of adults with hemiplegia uses a number of physiotherapy approaches developed by authors such as Bobath, Rood, Kabat, Brunnström and Perfetti.

The Bobath concept, also known as the neurodevelopmental technique (NDT) in the USA, is the most widely used approach in the rehabilitation of hemiparetic subjects in Europe, and it is well known and frequently used in many countries, including the USA, Canada, Japan, Australia and Israel. In recent years this approach has received increasing interest. Principles and techniques, described in Bobath's textbook of 1970 (1) and in the following edition of 1990 (2), have been modernized, incorporating new knowledge from neurophysiological research and motor development into the concept. The modern concept has been taught via an oral tradition in postgraduate courses and recent literature refers to Davies' textbook (3) and to Bobath's 1990 publication (2). Previous reviews on the subject of stroke rehabilitation and physiotherapy focused on literature concerning the theoretical basis of NDT (4, 5) or on the optimal approach to stroke rehabilitation, reviewing controlled trials only (6, 7). Furthermore, the retrieval and selection of studies for these reviews was not based on replicable and transparent methods; some trials could have been missed and their validity is uncertain. Given the popularity of NDT in treatment of adults with post-stroke hemiplegia, an overview of effectiveness evidence for the Bobath concept in rehabilitation of post-stroke hemiplegic patients is necessary in order to justify its wide use by physiotherapists. The aim of this review is to examine: (i) whether there is available evidence to accept the premise that NDT is effective; and (ii) if NDT is more effective than other treatments for adults with hemiplegia.

METHODS

A systematic literature search up to December 2001 was undertaken to identify relevant trials for this review. The following methods were used:

- the MEDLINE database was searched using combinations of the key words "rehabilitation", "physical therapy", "cerebrovascular disease", "stroke", "Bobath" and "hemiplegia" from 1980;
- the Cochrane Collaboration's register of trials and reviews was searched using the key words "cerebrovascular disease" and "stroke rehabilitation";
- the Physiotherapy Evidence Database (PEDro) was searched on the basis of "neurodevelopment treatment" and "neurofacilitation" categories.

In addition, reference lists and bibliographies of related journal articles and books were searched manually for additional trials.

All studies in the English, French and Italian languages, concerning effectiveness of the Bobath concept for adult hemiplegic patients were included: trials which use NDT in experimental groups or in control groups. Studies analysing the whole method or specific aspects of the method were included. Study design was not an exclusion criterion (e.g. only randomized controlled trials).

Exclusion criteria were: studies comparing NDT in addition to experimental treatment and NDT alone; trials on the effectiveness of NDT associated with other methods vs control (or experimental) treatment; effectiveness trials on the "Bobath roll"; studies on specific inhibition or facilitation techniques, no clearly expressed use of NDT. Care was taken to include each study only once, when multiple trials presented the same subjects and results.

The entire text of each article was read. From each study were abstracted: total number of subjects; age (mean and range); inclusion and/or exclusion criteria; time between stroke and start of trials; treatment of non-NDT group; main outcome measurements; blind assessment; follow-up; and the authors' conclusions.

Evidence of selected trials was classified according to Sackett's rules (8). According to Sackett, there are 5 levels of evidence for clinical interventions. At level 1 there are interventions that have been validated with randomized controlled trials (RCT) with low false-positive rates

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Table I. *Evidence for neurodevelopmental treatment for post-stroke hemiplegia*

Level	Description	Author (ref.)	Results
1	Large randomized trial with clear-cut results	None	
2	Small randomized trial with uncertain results	Langhammer et al. (15)	−
		Van der Lee et al. (24)	+/−
		Gelberet al. (14)	+/−
		Partridge et al. (23)	+/−
		Basmajian et al. (22)	+/−
		Mulder et al. (16)	+/−
3	Non-randomized, contemporaneous controls	Salter et al. (13)	+/−
		Dickstein et al. (11)*	+/−
		Lewis (10)	+
4	Non-randomized, historical controls	Hesse et al. (19)	−
		Hesse et al. (20)	−
		Wagenaar et al. (12)	+/−
5	No controls, case series only	Lennon (21)	+
		Hesse et al. (18)	+
		Hesse et al. (17)	−

+ = Positive results (substantial improvement in non-controlled trials and more improvement in controlled trials); − = negative results (no substantial improvement in non controlled trials or less improvement in controlled trials); +/− = no substantial differences berween groups in controlled trials. * Quasi randomized trial (depending on administrative procedures).

and high power. Level 2 considers interventions supported by RCT with high false-positive rates and low power. Level 3 is when non-randomized comparisons between contemporaneous groups have been used. Level 4 applies to non-randomized "historical" group comparisons, such as comparing one group treated according to local hospital procedures with another group previously treated at the same hospital. At level 5 there are case series without controls and where information is provided only on the outcome of patients without evidence of experimental design. For this review, limits between level 1 and level 2 were set at 30 subjects for sample size and $p < 0.001$ the statistical strength of evidence (9).

Moreover, selected trials were differentiated according to intervention goals.

RESULTS

A total of 15 trials were identified and are listed in Table I: 6 of them are RCT, 6 are non-randomized controlled trials (CT), 3 are case series. No trials have been classified on level 1 because of small samples or weak evidence from *p*-value. A total of 726 subjects entered the review, with a range from 1 to 148 in each trial. Age ranged from 15 to 95 years. Main inclusion and exclusion criteria are reported in Table II.

Selected trials refer to effectiveness of general treatment (10–15), treatment aimed at lower limb and/or gait (16–21) and upper limb (22–24). Population characteristics are summarized in Tables III, V and VII, and study characteristics in Tables IV, VI and VIII.

Three studies (13–15) report data on length of stay or rehabilitation costs. Galber et al. (14) show similar data for the 2 groups, with a not significative trend for more longer stays and rehabilitation costs in patients with NDT. Langhammer & Stanghelle (15) show a significantly ($p = 0.008$) longer hospitalization for NDT patients. Salter et al. (13) report no differences between the groups in terms of length of stay. All studies present no differences in the result.

Six trials refer to general treatment. The studies on general treatment include 387 subjects, age range 40–95 years. Two studies (14, 15) are RCTs, 2 (11, 13) are trials with contemporaneous control and Wagenaar et al. (12) performed a B-C-B-C single case experimental design. Salter et al. (13) and Lewis (10) consider NDT as a nursing approach.

Six trials refer to gait re-education. Hesse and colleagues performed 2 case series (17, 18) and 2 A-B-A single case study design alternating 3 weeks of each program and monitoring

Table II. *Main inclusion and exclusion criteria of selected studies*

	Criteria	References
Inclusion criteria	Motivation	12, 22
	Age <75–80 years	10, 12, 17, 22, 24
	First stroke	10, 12, 14, 15, 22
	Middle cerebral artery	12, 22
	Stroke <1 year	17, 22, 24
Exclusion criteria	Cognitive deficits or aphasia	12, 14, 16, 17, 18, 22, 23, 24
	Heart failure	17, 18, 19
	Additional orthopaedic, medical or neurological deficits	12, 13, 15, 17, 18, 19, 22, 23

Table III. *Studies on effectiveness of general treatment. Population characteristics*

Author	Subjects (*n*)	Mean age (range)	Start of rehabilitation
Langhammer et al. (15)	61	78 (49–95)	1–3 days
Gelber et al. (14)	27	NA	<1 month
Salter et al. (13)	80	61.2 (51–72)	NA
Wagenaar et al. (12)	7	NA (40–77)	5–9 days
Dickstein et al. (11)	131	70.5 (NA)	16 days
Lewis (10)	81	NA	NA

NA = data not available.

Table IV. *Studies on effectiveness of general treatment. Study characteristics*

Author	Different therapy group	Duration of rehabilitation	Blind evaluation	Outcome measures	Follow-up	Authors' conclusions
Langhammer et al. (15)	Motor Relearning Programme	NA	Yes	MAS; SMES; BI; NHP	No	BI, MAS, SMES improved more in MRP*
Gelber et al. (14)	TFR	NA	No	FIM; gait analysis; BBT; NPT	6 and 12 months	No differences
Salter et al. (13)	TFR	NA	No	LADS-II	No	No differences
Wagenaar et al. (12)	Brunnström	5 weeks (20 weeks)	No	ARAT; BI, gait speed and analysis	No	No differences
Dickstein et al. (11)	TFR; PNF	6 weeks	No	BI; strength; tone evaluation; gait analysis	No	No differences
Lewis (10)	TFR	NA	No	BI	No	More improvement in NDT group

BI = Barthel index; MAS = Motor Assessment Scale; SMES = Sodring Motor Evaluation Scale; NHP = Nottingam Health Profile; LADS-II = LORS American Data System Rating Scale; ARAT = Action Research Arm Test; FIM = Functional Independence Measure; BBT = Box & Block Test; NPT = Nine-hole Peg Test; PNF = Proprioceptive Neuromuscular Facilitation; TFR = Traditional Functional Retraining; NDT = Neurodevelopmental Treatment.
NA = data not available.
* The remaining investigations had no differences.

Table V. *Studies on effectiveness of treatment of lower limb and gait. Population characteristics*

Author	Subjects (*n*)	Mean age (years) (range)	Start of rehabilitation (range)
Lennon (21)	1	65	6 weeks
Hesse et al. (20)	7	50.9 (35–63)	26.4 weeks (13–41)
Hesse et al. (19)	7	60.3 (52–72)	>3 months (91–362 days)
Hesse et al. (18)	148	57.1 (15–84)	130.5 days (39–962)
Hesse et al. (17)	40	54.9 (15–74)	63 days (45–128)
Mulder et al. (16)	12	NA (34–68)	NA

NA = data not available.

subjects for 9 weeks (19) and 15 days of each treatment for an experimental period of 45 days (20). Lennon (21) describes gait re-education of 2 patients with hemiplegia but only 1 case satisfies inclusion criteria of this review. The studies on gait re-education include 215 subjects, age range 15–84 years and time interval from stroke onset 39–962 days. Duration of physiotherapy ranges from 4 weeks to 15 weeks. Outcome measures performed by gait analysis include gait symmetry and functional walking performance (16, 19, 20), vertical ground reaction forces measurements (18), or temporal-distance variables and joint angles, moments and powers (21).

Three trials refer to upper limb treatment (22–24). All studies are RCTs. The studies on arm re-education include 124 subjects, age range 22–86 years and time interval from stroke onset ranges from 3 weeks to 9.5 years. Duration of physiotherapy ranges from 2 weeks to 5 weeks.

Table VI. *Studies on effectiveness of treatment of lower limb and gait. Study characteristics*

Author	Different therapy group	Duration of rehabilitation	Blind evaluation	Outcome measures	Follow-up	Authors' conclusions
Lennon (21)	No	15 weeks	No	MAS; MCA; MASS; gait analysis	No	Improvement mobility and normal movement patterns
Hesse et al. (20)	Treadmill, MES	15 days (45 days)	Yes	FAC; RMA; MI; MASS	No	More improvement in MES group
Hesse et al. (19)	Treadmill	3 week (9 weeks)	No	FAC; RMA; MI; MASS; gait analysis	No	Gait ability and walking velocity improved more in treadmill*
Hesse et al. (18)	No	4 weeks	No	MI, gait analysis	No	Improvement normal movement patterns
Hesse et al. (17)	No	4 weeks	No	MI; gait analysis	No	Improvement functional gait parameters and MI
Mulder et al. (16)	EMG feedback	5 weeks	No	EMG activity; ROM; gait analysis	No	EMG activity improved more in EMG feedback*

MES = multichannel electrical stimulation; MAS = motor assessment scale; MCA = motor club assessment; FAC = functional ambulation category; RMA = Rivermead motor assessment; MI = motricity index; MASS = modified Ashworth spasticity scale; EMG = electromyographic; ROM = range of motion.
* The remaining investigations had no differences.

Table VII. *Studies on effectiveness of treatment of upper limb. Population characteristics*

Author	Subjects (*n*)	Mean age (years) (range)	Start of rehabilitation (range)
Van der Lee et al. (24)	30	61 (22–80)	3 years (1–20)
Partridge et al. (23)	65	64 (40–86)	33 weeks (3 weeks −9.5 years)
Basmajian et al. (22)	29	62 (39–79)	<12 months

Table VIII. *Studies on effectiveness of treatment of upper limb. Study characteristics*

Author	Different therapy group	Duration of rehabilitation	Blind evaluation	Outcome measures	Follow-up	Authors' conclusions
Van der Lee et al. (24)	Forced use	2 weeks	Yes	RAP; ARA; FMA; MAL; Problem score	1 year	More improvement in Forced Use for ARA*
Partridge et al. (23)	Cryotherapy	4 weeks	Yes	Verbal rating scale for pain; lateral rotation of the shoulder	No	Less frequent pain in NDT*
Basmajian et al. (22)	EMG feedback	5 weeks	Yes	UEFT; FOT; HBS; mood and affect tests	9 months	No differences

EMG = electromyographic; RAP = rehabilitation activities profile; ARA = action research arm test; FMA = Fugl-Meyer assessment scale; MAL = motor activity log; UEFT = upper extremity function test; FOT = finger oscillation test; HBS = health belief survey; NDT = neurodevelopmental treatment.
* The remaining investigations had no differences.

DISCUSSION

According to previous reviews (6, 7), no evidence has been found proving the effectiveness of NDT or supporting NDT as the optimal type of treatment. Two case series (18, 21) and 1 CT (10) report positive results; 1 non-controlled trial (17), 3 CT (10, 19, 20) and 1 RCT (15) report negative results; remaining studies (11–14, 16, 22–24) show no differences between compared groups. However, it should be noticed that the above-mentioned remaining RCT and CT show an improvement in all or some of measured parameters for NDT group.

There are several and particularly methodological problems in evaluating effectiveness of physiotherapy for adults with hemiplegia (7), and selected trials for this review present them in addition to others, tied to specific aspects of the Bobath concept.

Population characteristics, such as age, time since stroke, inclusion and exclusion criteria show how trials include little homogeneous patient samples, intra-trial and inter-trial. For this reason it is not possible to abstract information to understand which patient benefits from NDT and which does not, pointing out indications and contraindications of the concept, with

reference to age, sensory, cognitive or communicative problems and so on. For example, in the opinion of many Bobath therapists NDT should be applied preferably to people aged 55–75 years and it is difficult to justify pure Bobath for people over 80 years of age (25). No data from this review support this hypothesis. The limit between acute and chronic hemiplegia was fixed within 6 months, because during this period effects of spontaneous recovery cannot be excluded (26). Controlled trials should include either acute or chronic patients, because spontaneous recovery could bias results. In this review 1 RCT (16) and 2 CT (10, 13) do not report when rehabilitation started and 3 CT include chronic and acute patients together (19, 22, 23). On the other hand, non-controlled trials should include only chronic subjects, otherwise effects of spontaneous recovery is not excluded. Two case series assess acute subjects (17, 21) and the third includes acute and chronic patients together (18).

Also treatments and outcome measures present little homogeneity. In fact, controlled trials were performed using 9 different types of intervention, duration of rehabilitation and outcome measures have a variability that makes results difficult to compare. The most frequently used outcome measures were functional scales or tests. Functional measurements alone are not suitable to assess Bobath treatment effects, because they are able to show only improvement of functional ability, but not that motor recovery has occurred on the affected side, as searched by physiotherapists using NDT. All trials on gait re-education use gait analysis, but different aspects were assessed.

An important aspect of the Bobath concept is the treatment of tone anomalies. Two studies (11, 19) consider this, but they do not support Bobath's claim that the techniques exert a special influence on muscle tone and the superiority of the Bobath approach in decreasing muscle tone when compared with other approaches. This is supported by other researchers. Dickstein & Pillar (27) examine the effects of reflex-inhibiting patterns using electromyographic feedback and no effects on reduction of muscle tone were found. Hesse et al. (28) found an increasing trend of extensor spasticity of the plantar flexor during gait with therapeutic facilitation according to the NDT technique compared with walking with and without a cane. On the contrary recent studies (29) show how sustained muscle stretch is able to reduce enhanced motoneuronal excitability. At present Bobath physiotherapists do not use reflex inhibiting patterns but they try to control muscle tone during functional performances. Muscle tone measurement is considered not very accurate. For example, the Ashworth Spasticity Scale (original and modified form) is a commonly used scale to assess muscle spasticity, but its reliability and construct validity is questioned by several studies (30).

Only 4 authors (12, 15, 21, 22) described in detail the contents of treatment sessions or use standardized protocols. Different types of treatment could have been used by the other authors, because physiotherapy depends upon the expertise of the physiotherapists, their understanding of the implications of the theory on which the Bobath approach is based and upon the current framework of the approach at the moment of the study.

Follow-up is present in few studies (14, 22, 24) and only one explains treatment during the period between the experimental treatment and the follow-up (no treatment) (22).

Trials on upper limb rehabilitation are well-designed studies, all of them are single-blinded RCTs; trials on general treatment are controlled trials, but one is a double-blind RCT (15), remaining investigations are controlled trials classified at levels 3 (10, 11, 13) and 4 (12). Trials on lower limb or gait re-education are classified at levels 2 (16), 4 (19, 20) and 5 (17, 18, 21).

RCTs are recognized as the best method of comparing the effectiveness of different treatments but controlled studies included in this review investigate relative effectiveness of NDT. On the other hand, Morley (31) judged single case series a suitable way to investigate effectiveness of an intervention, because of subjects variability, but the evidence from single case studies is weak. So, none of the selected studies analyse real effectiveness of the Bobath concept. A suitable method to examine effectiveness of an approach such as NDT should be a RCT comparing a non-specific physiotherapy group with an experimental group treated with the same non-specific physiotherapy plus specific aspects of NDT (e.g. gait re-education) equally intensive and frequent. Subjects should be included in homogenous groups for age, cerebral damage characteristics, associated problems, start of rehabilitation and so on. Important problems concern outcome measures. One of the most important goals of Bobath therapists is to obtain normal movement patterns in their patients (32). The quality of movement is an important aspect of the quality of life, but, at the moment, its measure is difficult to standardize. So, the real benefits of the Bobath approach may have been underestimated because of the functional outcome measures used in the trials selected for this review. In fact, changes in movement can be achieved following rehabilitation (21) and specific manoeuvres (28) based on the Bobath concept. Particular aspects of movement analysis, such as shown by Lennon (21) and Hesse et al. (28), seem to be a promising way to analyse patterns of movement.

Few studies (13–15) report data on cost-benefit of use of NDT for adult patients and 2 of them report a longer hospitalization for NDT groups. Moreover, Lord & Hall (33) also found, in a retrospective study comparing traditional functional retraining with neuromuscular functional retraining, an eclectic approach including NDT, a significantly longer rehabilitation hospitalization ($p = 0.001$) for neuromuscular functional retraining group, with no difference between groups in terms of skill levels. This is an important aspect of effectiveness evaluation, which should be considered when rehabilitation programs are assessed or applied (6, 25).

Limitations

Some trials could not be included in this review because several authors, particularly regarding control groups, report conventional treatment without explaining what type of procedures they

used. This kind of error must be taken into account, because many of the selected studies consider NDT as traditional physiotherapy (16, 19, 20, 22). Moreover, 2 search strategies (no. 2 and no. 3) mainly concern controlled trials and additional databases were not searched.

One possible criticism is that statistical methodologies have not been assessed or discussed. Classification according to the hierarchic scale of evidence for clinical interventions based on study designs and abstracted elements have been judged adequate for the purpose of this review.

CONCLUSION

The purpose of this paper was to determine whether there is evidence regarding the Bobath concept for adults with hemiplegia following a cerebrovascular accident. For this goal an extensive review with critical appraisal of studies was conducted. Selected trials show no evidence proving the effectiveness of NDT or supporting NDT as the optimal type of treatment, but neither do they show evidence of non-efficacy, because of methodological limitations.

The Bobath concept must be defined, and standardized guidelines for treatment must be identified and described. Further investigations are necessary to develop outcome measures concerning goals of the Bobath approach, such as quality of motor performance, determine which patient benefits from NDT and which does not, pointing out its indications and contra-indications and determine the real effectiveness of NDT in treatment of post-stroke hemiplegia. The cost/benefit ratio should also be considered.

REFERENCES

1. Bobath B. Adult hemiplegia. Evaluation and treatment. London: Heinemann; 1970.
2. Bobath B. Adult hemiplegia. Evaluation and treatment. London: Heinemann; 1990.
3. Davies PM. Steps to follow. Heidelberg: Springer-Verlag Berlin; 1985.
4. Keshner EA. Reevaluating the theoretical model underlying the neurodevelopmental theory. A literature review. Phys Ther 1981; 61: 1035–1040.
5. Lennon SM. The Bobath concept: a critical review of the theoretical assumptions that guide physiotherapy practice in stroke rehabilitation. Phys Ther Rev 1996; 1: 35–45.
6. Ernst E. A review of stroke rehabilitation and physiotherapy. Stroke 1990; 21: 1081–1085.
7. Ashburn A, Partridge CJ, De Souza L. Physiotherapy in the rehabilitation of stroke: a review. Clin Rehabil 1993; 7: 337–345.
8. Sackett DL. Rules of evidence and clinical recommendations on the use of antithrombotic agents. Chest 1986; 89 (suppl 2): 2s–3s.
9. Sterne JAC, Smith GD. Sifting the evidence—what's wrong with significance tests? BMJ 2001; 322: 226–231.
10. Lewis NA. Functional gains in CVA patients: a nursing approach. Rehabil Nurs 1986; 11: 25–27.
11. Dickstein R, Hocherman S, Pillar T, Shaham R. Stroke rehabilitation: three exercise therapy approaches. Phys Ther 1986; 66: 1233–1238.
12. Wagenaar RC, Mejier OG, Van Wieringen PC, Kuik DJ, Hazemberg GJ, Lindeboom J, et al. The functional recovery after stroke: a comparison between neuro-developmental treatment and the Brunnstrom method. Scand J Rehabil Med 1990; 22: 1–8.
13. Salter J, Camp Y, Pierce LL, Mion LC. Rehabilitation nursing approaches to cerebrovascular accident: a comparison of two approaches. Rehabil Nurs 1991; 16: 62–66.
14. Gelber DA, Josefczyk PB, Herrman D, Good DC, Verhulst SJ. Comparison of 2 therapy approaches in the rehabilitation of pure motor hemiparetic stroke patients. J Neuro Rehab 1995; 9: 191–196.
15. Langhammer B, Stanghelle JK. Bobath or motor relearning programme? A comparison of two different approaches of physiotherapy in stroke rehabilitation: a randomized controlled study. Clin Rehabil 2000; 14: 361–369.
16. Mulder T, Hulstijn W, van der Meer J. EMG feedback and the restoration of motor control. A controlled group study of 12 hemiparetic patients. Am J Phys Med 1986; 65: 173–188.
17. Hesse SA, Jahnke MT, Schreiner C, Mauritz KH. Gait symmetry and functional walking in hemiparetic patients prior to and after a 4-week rehabilitation programme. Gait Posture 1993; 1: 166–171.
18. Hesse SA, Jahnke MT, Bertelt CM. Gait outcome in ambulatory hemiparetic patients after a 4-week comprehensive rehabilitation program and prognostic factors. Stroke 1994; 25: 1999–2004.
19. Hesse S, Bertelt C, Jahnke MT, Schaffrin A, Baake P, Malezic M, Mauritz KH. Treadmill training with partial body support compared with physiotherapy in non-ambulatory hemiparetic patients. Stroke 1995; 26: 976–981.
20. Hesse S, Malezic M, Schaffrin A, Mauritz KH. Restoration of gait by combined treadmill training and multichannel electrical stimulation in non-ambulatory hemiparetic patients. Scand J Rehabil Med 1995; 27: 199–204.
21. Lennon S. Gait re-education based on the Bobath concept in two patients with hemiplegia following stroke. Phys Ther 2001; 81: 924–935.
22. Basmajian JV, Gowland CA, Finlayson MA, Hall AL, Swanson LR, Stratford PW, et al. Stroke treatment: comparison of integrated behavioral physical therapy vs traditional physical therapy programs. Arch Phys Med Rehabil 1987; 68: 267–272.
23. Partridge C, Edwards S, Mee R, Langenberghe H. Hemiplegic shoulder pain: a study of two methods of physiotherapy treatment. Clin Rehabil 1990; 4: 43–49.
24. van der Lee JH, Wagenaar RC, Lankhorst GJ, Vogelaar TW, Devillé LW, Bouter LM. Forced use of the upper extremity in chronic stroke patients: results from a single-blind randomized clinical trial. Stroke 1999; 30: 2369–2375.
25. Panturin E. The Bobath concept. Letters to the editor. Response. Clin Rehabil 2001; 15: 111–113.
26. Gresham GE, Duncan PW, Stason WB, Adams HP, Adelmen AM, Alexander DN, et al. Post-stroke rehabilitation. Clinical Practice Guidelines, No 16. Rockville, MD: US, Department of Health and Human Service. Public Health Service, Agency for Health Care Policy and Research. AHCPR Publication No. 95-0662. May 1995.
27. Dickstein R, Pillar T. Evaluating the effects of reflex-inhibiting patterns among hemiplegic patients using EMG biofeedback. Physiother Can 1983; 35: 141–143.
28. Hesse S, Jahnke MT, Schaffrin A, Lucke D, Reiter F, Konrad M. Immediate effects of therapeutic facilitation on the gait of hemiparetic patients as compared with walking with and without a cane. Electroencephalogr Clin Neurophysiol 1998; 109: 515–522.
29. Hummelsheim H, Munch B, Butefisch C, Neumann S. Influence of sustained stretch on late muscular responses to magnetic brain stimulation in patients with upper motor neuron lesions. Scand J Rehabil Med 1994; 26: 3–9.
30. Fritz JM, Wainner RS. Examining diagnostic tests: an evidence-based perspective. Phys Ther 2001; 81: 1546–1564.
31. Morley S. Single case research. In: Parry G, Watts FN, eds. Behavioural and mental health research: a handbook of skills and methods. Lawrence Erlbaum: London, 1989.
32. Lennon S, Asburn A. The Bobath concept in stroke rehabilitation: a focus group study of the experienced physiotherapists' perspective. Disabil Rehabil 2000; 22: 665–674.
33. Lord JP, Hall K. Neuromuscular reeducation versus traditional programs for stroke rehabilitation. Arch Phys Med Rehabil 1986; 67: 88–91.