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ITALIAN JOURNAL OF PHYSIOTHERAPY

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Società Italiana di Fisioterapia

CONTENTS

The Italian Journal of Physiotherapy: the S.I.F. voice in order to participate at the International Physiotherapists Community

R. GATTI

San Raffaele Scientific Institute, Milan, Italy

This is the first issue of the Italian Journal of Physiotherapy (IJP). The IJP is the scientific journal of the Italian Society of Physiotherapy (S.I.F.). In order to better introduce the IJP I would like to present the newly-founded S.I.F..

The S.I.F. was founded in May 2010. The objective of the S.I.F. is to promote and facilitate the development of scientific culture in the field of Italian Physiotherapy. As a demonstration of the Italian physiotherapists' expectation of such initiative the number of founding members must be considered. Indeed, from an initial number of 16 physiotherapists that had the idea to propose the initiative, more than 150 physiotherapists have gathered on the day of the foundation of the S.I.F..

Considering this event some questions spontaneously arise.

The first question is: why so much participation of Italian colleagues in the S.I.F. foundation? In recent years the habit of comparing clinical behaviors with the best evidence presented in literature has sharply increased among Italian physiotherapists.

As a matter of fact, the university Italian programs included in recent years an increasing number of teachings about methodological approach to the clinical practice and scientific research. A scientific approach to the clinical problems is bringing the Italian physiotherapists to align their work with the scientific context, easily available from the literature.

Nevertheless, few opportunities for sharing the clinical experiences exist and it is common that an Italian physiotherapist involved in scientific activity is not known by the rest of the Italian colleagues. The main reason for the great adhesion at the S.I.F. is a widespread desire to create a community in which to compare and develop clinical and scientific experiences.

So, what is the mission and the vision of the S.I.F.? The 2011 S.I.F. catch-phrase is: "to promote scientific culture as an opportunity to deepen clinical experience". Sometimes some colleagues consider the scientific culture as only theory and for them it becomes a hindrance to the clinical practice. The truth is exactly the opposite. To find the best treatment for each patient, comparing one's own clinical experience with the scientific literature means to consider reality more than theories. It is also true that no physiotherapist can plan his/her treatment only using data emerging from the literature. The physiotherapists that decided to promote the S.I.F. know that the evidence-based medicine (EBM) or the evidence-based practice (EBP) should not become a new ideology. EBM and EBP are not unconnected to the clinical experience but they are the most reasonable way to try to solve some of the contradictions existing in the rehabilitation field. For example: is it intellectually honest not to consider data emerging from the literature, when any? What are the criteria to choose between two rehabilitative tech-

niques with very different rationales? Is it logical not to consider data that contradict the rationale considered correct? The objective of the S.I.F. is to promote the scientific culture not for removing but for deepening the clinical experience.

So far I have spoken of the S.I.F. and not of the IJP, therefore the third question is: why can the IJP help the S.I.F. in promoting its objectives?

Because the ideas and also the ideality need actions performed by people. Without this condition they become a useless intellectual exercise.

The IJP aspires to represent the S.I.F. in the International Physiotherapists Community. My experience leads me to speak about Community. Especially in occasion of both International Congress and events organized in Italy I met many foreign colleagues (some of them are on the board of the IJP) and the modality of relationship that I felt brings me to use the term "Community". I mean that the aim in sharing own cultural and scientific experiences is the development of a common discipline, *i.e.* physiotherapy, in which we all spend not only our energies but also our ideality. This is not a small thing, in a period where the affirmation of personal power sometimes seems to be the only objective of human actions.

The aim of IJP is to become an indexed peer review journal in some years. This is an ambitious project and for its realization the quality of the product should engage the interest of Italian and foreign colleagues. It is an intriguing challenge that I hope will involve young physiotherapists.

My dream is to see, in a near future, a group of young physiotherapists proposing themselves for the continuation of the activities that the S.I.F. are developing. Even more I would like the IJP to be able to become an instrument in the hands of young physiotherapists.

To look at the future requires knowing one's own roots. In occasion of the first issue of the IJP I asked Professor Silvano Boccardi, to whom I am linked by a deep friendship, to write a greeting introduction for the IJP. Professor Boccardi is one of the fathers (even if he affirms his regret for not remembering the mother) of Italian Rehabilitation. He is the physician that more or less 60 years ago founded the first Italian school of physiotherapy and, subsequently set up a lot of scientific initiatives in the rehabilitation field.

Over many years Italian physiotherapists have learnt to identify and promote their discipline and now they are knocking at the door of the international Physiotherapist Community as a Scientific Association, thanks to the work of many of them and the passion that people such as Professor Boccardi have demonstrated.

A combination of motor imagery, action observation and motor execution is highly effective for the acquisition of a complex coordination behaviour

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ABSTRACT

Aim. Motor imagery (MI) and action observation (AO) are emerging cognitive tools for motor learning, since they share with motor execution (ME) similar patterns of cortical areas activation. This study was aimed at investigating whether the combination of MI, AO and ME is as effective as ME alone for the acquisition of a complex coordination behavior.

Methods. Thirty-six healthy subjects (age 24.4±4.1) were randomly divided into three groups: physical practice (PP), mental+physical practice (MP) and control (C). The studied task was a multifrequency bilateral full-range wrist flexion-extension, with left hand moving twice as fast as the contralateral. Participants underwent a single-session training period, comprising 12 minutes of ME (PP), 4 minutes each of AO, ME, MI (MP) or 4 minutes of ME (C). Movement amplitude and frequency were calculated for both right and left limbs at baseline and in two retention tests. The main outcome measure was the ratio between right and left hand movement frequency. Motor learning in the three groups was compared by a 3x3 ANOVA with repeated measures.

Results. The training was similarly effective in PP and MP groups, who both significantly improved their ability in pacing the target frequencies and amplitudes, whereas participants in C group remained unchanged.

Conclusion. When using ad adequate scheduling of learning periods, the combination of MI, AO and ME may be as effective as ME alone. This finding may contribute to develop new effective therapeutic methods in neurorehabilitation. *(It J Physiother 2011;1:3-11)*

Key words: Motor skills disorders - Mental processes - Kinesthesis.

Motor imagery (MI) is a cognitive process during which a subject imagines the execution of a specific movement without any motor output, whereas action observation (AO) refers to the observation of a movement performed by another person.[1] Both MI and AO are emerging cognitive tools for motor learning, based on the finding that they share with motor execution (ME) similar patterns of activation in cortical areas.[2-5] On the whole, published data support the idea that both these movement-related cognitive phenomena are driven by the same basic mechanisms as ME and therefore can be conceived as offline operations of the motor system.[1]

The imagination may be performed in a first person (kinesthetic MI) or in a third person (visual MI) perspective.[1] Kinesthetic MI refers to the imagination of the sensory consequences resulting from the execution of the movement, *i.e.* the subject internally simulates all the kinesthetic sensations associated with the imagined movement. In visual MI, the subject sees him/her self doing the movement as from a distance, *i.e.* the virtual environment is imagined. Several researchers have shown that MI facilitates the learning of movements in healthy subjects and in sports activities [6-11] and some evidence exists about its effectiveness in a patient-related con-

text.[12-17] On the whole, the notion emerged that mental practice with MI is effective in facilitating motor learning, but not as effective as physical practice.[18]

The indirect evidence for the existence in humans of a system of mirror neurons, *i.e.* neurons firing with both action observation and action execution,[4, 19-20] led in recent years to implement strategies based on a different type of mental practice, *i.e.* AO, for motor learning [21] and in stroke rehabilitation.[22-24]

The observation of the task to be learned and an actual execution of the task are obvious prerequisites for the correct performance of the visual MI and the kinesthetic MI, respectively[25]. Therefore, we may speculate that, in order to optimise its effects on motor learning, MI should be combined with both AO and ME, but insofar this hypothesis has not been verified. This study was aimed at investigating whether the combination of MI, AO and ME is as effective as ME alone in the learning of a relatively complex bimanual multifrequency motor task in health subjects.

Materials and methods

Subjects

A convenience sample of 36 young right-handed participants, 21 women and 15 men, with a mean age of 24.4±4.1 (range 20-39), was enrolled in the study. None had known history of neurological or muscle-skeletal disorders that might have influenced their muscle strength and coordination. Right limb preference was ascertained through the Edinburgh Inventory.[26] Additional exclusion criteria were the presence of serious sight problems or cognitive impairments. Amateur or professional musicians also were excluded, since they are usually well trained to rhythmically move their hands at different speed. All participants gave their written informed consent.

Task

Participants were asked to learn a relatively complex bimanual multifrequency task, such that the left limb moved twice as fast as the contralateral (2:1 frequency ratio). Movements were cyclical wrist flexion and extension with finger joints held adducted and extended, and were paced by a quartz metronome (Taktell QM2, Wittner, Isny/Algäu, Germany) producing a beat every 476 ms (2.1 Hz). For every beat, subjects were required to complete an entire flexion-extension cycle with the left arm, while the right wrist only performing the movement in one direction (alternatively flexion or extension). As such, the same turning point had to be reached on every beat by the fast hand (2.1 Hz) and on every two beats by the slow hand (1.05 Hz). For both limbs, the required movement amplitude was the full flexion-extension range, but no targets were used to indicate the completion of the range.

Participants performed the task while sitting on an adjustable chair with their arms in slight (30°) flexion and their forearms pronated and supported by armrests.

Procedure

Participants were randomly divided into three groups: physical practice (PP), mental practice (MP) and control. All groups practiced the task during one single training session which was divided into a first and a second learning phases, with a 3 minute resting period between the two phases, and which lasted 25 minutes overall. The scheduling of practice periods in the three groups was as follows.

1) PP. This group performed three blocks of practice of the task during both learning phases, each block consisting in four 30 seconds periods of ME of the task; time intervals were 60 and 20 seconds among blocks and periods, respectively. Participants in this group performed a total of 24 periods for an overall duration of 12 minutes of ME.

2) MP. This group also performed three blocks of four in 30 second periods of practice in each learning phases, with the same resting intervals among blocks and periods as the PP group, but alternated PP and MP of the task. The first block consisted in four periods of AO, during which subjects watched to a video showing an individ-

ual correctly performing the task to be learned. The second block was the same as for the PP group, *i.e.* four periods of ME of the task. In the third block this group imagined the execution of the task, alternating visual and kinesthetic MI periods. This group, therefore, performed a total of 24 periods for an overall duration of 4 minutes of ME, 4 minutes of AO, 2 minutes of first perspective MI and 2 minutes of third perspective MI.

3) Control (C). This group practiced the task to be learned only in the second block of the two learning phases, which consisted in four 30 seconds periods of ME as for the other groups. In the remaining periods (blocks 1 and 3), participants were asked to watch to naturalistic movies lasting 3 minutes. At the end of the vision, three questions about the information presented in the movies were asked to participants, in order to verify that they had not been concentrating on the bimanual task during these periods. Thus in this group the actual training of the task was limited to 4 minutes of ME.

Before starting the training phase, the baseline ability of each participant in performing the task was assessed. During the baseline assessment, named pre-Test, subjects performed one single 30 seconds trial for each of three conditions, in the following order:

1) unimanual left test (ULT): cyclical wrist flexion-extension movements of the nondominant left hand at 2.1 Hz;

2) unimanual right test (URT): cyclical wrist flexion-extension movements of the dominant right hand at 1.05 Hz;

3) bimanual multifrequency test (BMT): bilateral wrist flexion-extension movements with a 2:1 frequency ratio between the left (fast) and the right (slow) hand.

The first two conditions were used to verify participants' ability in pacing the target frequencies when moving the fast and the slow hand separately, whereas the third condition assessed their baseline ability in performing the bimanual task to be learned. The required movement amplitude was the full flexion-extension range throughout. All conditions were paced at 126 beats per minute (2.1 Hz).

To detect the effects of different training protocols, all participants completed two retention tests, three minutes (immediate, R_imm) and one hour (delayed, R_del) after the completion of the training session. During both retention tests, only condition 3 (bimanual test) was assessed. All bimanual tests (Test, R_imm, R_del) were preceded by a verbal description and a video demonstration of the required task. For the latter, participants watched to the same 30 second video used for AO training periods in the MP group. Limited to baseline assessment, they were allowed also to freely practice the bimanual task for 60 seconds before starting the bimanual test.

To detect kinematic data, all assessment trials were recorded by an optoelectronic motion analysis system (SMART-e 900, BTS, Milan, Italy) using passive reflective markers and four infrared cameras, set at a 60 Hz acquisition frequency. To capture hand movements, one reflective hemispherical marker (cm 1.5 in diameter) was placed on the dorsal surface of the middle finger nail bilaterally.

Only in MP group, participants' imagery ability was assessed before starting the training session asking them to complete the shortened version of the Movement Imagery Questionnaire (MIQ).[27] This test is comprised of four visual and four kinesthetic imagery items, involving movements of an arm, a leg or the entire body. For each item, subjects imagine the movement after one single physical execution. They are then asked to rate the difficulty in picturing/feeling the movement on a 7-point scale anchored by 1 (=very easy) to 7 (=very difficult). The same 7-point scale was also used during the training session, asking participants in the MP groups, after each IM period, to estimate their difficulty in imaging the bimanual task.

Statistical analysis

To avoid anticipation effects associated with the beginning and the end of a trial, the first and last 2.5 seconds of data were excluded from all analyses.

First, the cycle duration was defined as the time (in ms) elapsing between two successive peak extension positions. The target cycle duration values were 476 and 952 ms for the slow (right) and

the fast (left) hand, respectively. For each cycle, the movement frequency was obtained for each limb by dividing 1000 by the cycle duration. The mean value of the movement frequency were then calculated for both unimanual and bimanual conditions. The frequency ratio between right and left limb was obtained for the performance in the bimanual condition (FR_Bim) at pre-Test, R_Imm and R_Del, by dividing the averaged right hand movement frequency by the averaged left hand movement frequency. Any deviation from a 0.5 ratio reflected deviations from a perfect 1:2 frequency performance. At baseline assessment, the right-left limb ratio was also calculated for the unimanual conditions (FR_Uni) in order to detect participants' ability in pacing the target frequencies when their performance was free of inter-limb interference. Finally, bimanual-unimanual frequency ratios (FR_Bim/Uni) were calculated for both right and left hand by dividing the average movement frequency in the bimanual test measured at each assessment (Test, R_imm, R_del) by the average movement frequency in the unimanual test at baseline assessment (Test). Any deviation from the target value (=1) for these ratios reflects errors in pacing the target frequency during bimanual performance. Therefore, they were computed to detect whether the performance in the bimanual condition deteriorated differently in the fast and in the slow hand.

Peak to-peak amplitude values were also calculated per cycle and averaged across trials for each of the different conditions. For each hand, bimanual-unimanual amplitude ratios (AR_Bim/Uni) were then obtained by dividing the mean range of movement during bimanual task, calculated for each of the three session of assessment (pre-Test, R_Imm and R_Del), by the mean range of movement during unimanual task at the baseline assessment.

χ^2 test for comparisons of proportions and one-way ANOVA for mean values were used to compare participants demographic characteristics and baseline ability in the bimanual task among the three groups. For each outcome measure, a 3 x 3 ANOVA with repeated measures with two factors, Time (pre-Test, R_Imm, R_Del) and Group (PP, MP, C), was used to compare motor learning among groups. *Post-hoc* analyses were conducted comparing groups two by two. Limited to MP group, MIQ scores were compared to participants' estimate about their difficulty in picturing/feeling the bimanual task using a paired t-test.

The level of statistical significance was set at 0.05. Data analyses were performed using MS Excel 2003 and the SPSS statistical package 15.0 for Windows.

Table I.—*Demographic characteristics of the study population and results at baseline assessment.*

	PP (N.=12)	MP (N.=10)	C (N.=14)	P
Age, years (mean ± SD)	25.7± 5.1	23.0± 2.4	24.4± 4.0	0.320
Gender (male/female)	4/8	6/4	5/9	0.381
FR_Uni (mean ± SD)	0.50± 0.01	0.50± 0.01	0.51± 0.02	0.452
FR_Bim (mean ± SD)	0.81± 0.23	0.82± 0.20	0.88± 0.16	0.654
FR_Bim/Uni RH (mean ± SD)	1.48± 0.45	1.52± 0.32	1.60± 0.41	0.743
FR_Bim/Uni LH (mean ± SD)	0.93± 0.15	0.95± 0.11	0.93± 0.16	0.935

PP: physical practice group; MP: mental+physical practice group; C: control group; FR_Uni and FR_Bim: frequency ratio (right hand movement frequency/left hand movement frequency) in unimanual and bimanual test, respectively; FR_Bim/Uni: frequency ratio between bimanual and unimanual tests (bimanual test frequency/unimanual test frequency); RH: right hand; LH: left hand.

Results

Of the 36 subjects enrolled, twelve were randomised to physical practice, ten to physical+mental practice and fourteen to control group. The demographic data and the ability in the unimanual and in the bimanual task were similar in the three groups at baseline (Table I).

At initial assessment, all groups were able to pace almost perfectly the target frequencies when moving each hand separately; their performance, however, clearly deteriorated during the bimanual task, as shown by a FR_Bim mean value of more than 0.80 in all groups. Errors in the bimanual task were mainly due to participants' inability to pace the target frequency with

Table II.—*Effects of the training on participants' ability in pacing the target frequencies with the slow (right) and the fast (left) hand.*

	PreTest	R_Imm	R_Del
*FR_Bim * § #*			
Physical practice (N=12)	0.81± 0.23	0.53± 0.04	0.54± 0.05
Mental+Physical practice (N=10)	0.82± 0.20	0.56± 0.08	0.56± 0.06
Control (N=14)	0.88± 0.16	0.90± 0.13	0.92± 0.10
*FR_Bim/Uni RH * § #*			
Physical practice (N=12)	1.48± 0.45	1.07± 0.09	1.11± 0.13
Mental+Physical practice (N=10)	1.52± 0.32	1.15± 0.17	1.13± 0.13
Control (N=14)	1.60± 0.41	1.69± 0.32	1.74± 0.31
*FR_Bim/Uni LH ** *			
Physical practice (N=12)	0.93± 0.15	1.02± 0.04	1.02± 0.04
Mental+Physical practice (N=10)	0.95± 0.11	1.02± 0.05	1.01± 0.03
Control (N=14)	0.93± 0.16	0.96± 0.16	0.97± 0.14

*Time, P<0.001; **Time, P<0.005; §Group, P<0.001; #Time x group, P<0.001. FR_Uni and FR_Bim: frequency ratio (right hand movement frequency/left hand movement frequency) in unimanual and bimanual test, respectively; FR_Bim/Uni: frequency ratio between bimanual and unimanual tests (bimanual test frequency/unimanual test frequency); RH: right hand; LH:left hand; PreTest: baseline assessment; R_Imm: immediate retention test; R_Del: delayed retention test. Data are shown as mean and SD.

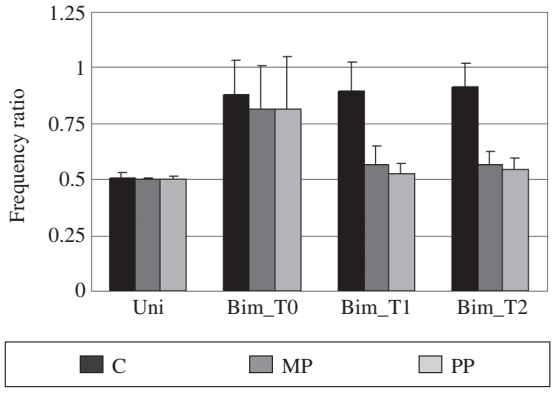

Figure 1.—Mean±SD of movement frequency ratio between the right (slow) and the left (fast) hand during unimanual test (Uni) e during bimanual performance at pre-test (Bim_T0) and at immediate (Bim_T1) and delayed (Bim_T2) retention test in the three groups (C=control group; MP=mental+physical practice group; PP=physical practice group).

the right (slow) hand, rather than with the left (fast) hand. The FR_Bim/Uni, in fact, clearly deviated from the target value (=1) only in the right hand, whereas in the non dominant hand it reflected an almost perfect performance.

The effects of training are shown in Tables II, III. Statistical analysis showed a highly significant effect of Time ($F_{2\text{-}66}$=23.54, P<0.001) and of Group ($F_{1\text{-}33}$=34.242, P<0.001) on FR_Bim. Moreover, the Time x Group interaction was also significant ($F_{4\text{-}66}$=9.221, P<0.001), indicating that improvements in participants' ability to pace the target frequency ratio during bimanual task differed among the three groups. *Post-hoc* analyses revealed that there were no differences between PP and MP groups, whereas they both differed from C group (Time x Group interaction: MP vs C, $F_{2\text{-}44}$=16.049, p<0.001; PP vs C, $F_{2\text{-}48}$=15.039, p<0.001). On average, participants in the PP and MP groups neared the optimal frequency ratio at R_Imm and maintained this ability at R_Del, while performance of C group did not vary among the three sessions of assessment (Table II, Figure 1). The comparison of movement speed of right and left hand during unimanual and bimanual task confirmed that, after the training period, participants of PP and MP groups had learned to approximate the target frequencies with both hands, not merely to reach a 1:2 ratio between the two hands (Table II). For right hand FR_Bim/Uni, in fact, the analysis showed significant effects of Time ($F_{2\text{-}66}$=9.448, p<0.001), Group ($F_{1\text{-}33}$=17.283, P<0.001) and Time x Group interaction ($F_{4\text{-}66}$=6.126, P<0.001). Again, *post-hoc* analysis demonstrated significant differences between both PP and MP groups and C group (Time x Group interaction: MP vs C, $F_{2\text{-}44}$=11.098, P<0.001; PP *vs.* C, $F_{2\text{-}48}$=8.268, P<0.005). Conversely, no differences among groups were found in left hand FR_ Bim/Uni. This finding indicates that participants in PP and MP groups had learned to slow down the right hand movement without significantly affecting the speed of the contralateral hand, whereas participants in C group had not.

With regard to movement amplitudes, results confirm the finding that participants in PP

Table III.—*Effects of the training on participants' ability in moving the slow (right) and the fast (left) hand through the full flexion-extension range during the bimanual test, compared to the unimanual test.*

	PreTest	R_Imm	R_Del
*Right hand AR_Bim/Uni * § #*			
Physical practice (N.=12)	0.84± 0.15	0.98± 0.13	0.93± 0.13
Mental+Physical practice (N.=10)	0.87± 0.11	0.98± 0.18	0.96± 0.10
Control (N.=14)	0.83± 0.12	0.82± 0.12	0.80± 0.13
Left hand AR_Bim/Uni			
Physical practice (N.=12)	0.98± 0.14	0.94± 0.19	0.95± 0.13
Mental+Physical practice (N.=10)	1.00± 0.07	0.95± 0.16	0.93± 0.17
Control (N.=14)	1.04± 0.16	1.00± 0.17	1.00± 0.23

*Time, P<0.01; §Group, P<0.05; #Time x group P<0.05. AR_Bim/Uni: amplitude ratio between bimanual and unimanual tests (mean bimanual test movement amplitude/mean unimanual test movement amplitude; PreTest:baseline

and MP groups learned to execute the multifrequency bimanual task significantly better than C group (Table III). For the left hand, AR_Bim/Uni was always close to the target value (=1) and no significant changes were found among groups and among sessions of assessment. In all groups, at the baseline assessment AR_Bim/Uni for the right hand was less than one, indicating a reduced mean range of motion during the bimanual test compared to the unimanual test. After the training period, however, this value increased in PP and MP groups, while remaining relatively unchanged in C group (Figure 3), as inferred by the significant effect of Time (F_{2-66}=5.432, P=0.007), Group (F_{1-33}=4.484, P=0.019) and Time x Group interaction (F_{4-66}=2.795, P=0.033). Post-hoc test revealed significant differences between PP and C groups (Time x Group interaction, F_{2-48}=4.652, P<0.05), whereas differences between MP and C groups were not significant (Time x Group interaction, F_{2-44}=2.515, P=0.092).

MIQ scores reported by participants in group MP indicated an average to high difficulty in picturing (visual MI, 5.8±0.8, range 4.5-6.8) or feeling (kinaesthetic MI, 4.8±0.9, range 3.8-6.3) the motor tasks of the questionnaire. Compared to MIQ scores, participants' estimate was slightly less for the task to be learned (visual MI, 5.1±1.0, range 3-6.5; kinaesthetic MI, 4.3±0.9, range 3-5.5), but the differences were not significant (P=0.159 and P=0.189 for visual and kinaesthetic MI, respectively).

Discussion

The present findings indicate that in healthy young persons a training which combine ME with MI and AO is highly effective for the acquisition of a bimanual coordination task. Early studies on mental practice found it to be more effective when the practised tasks have cognitive components which are dominant compared to the motor ones.[28] The task employed in the present study, however, may be considered a relatively "pure" motor skill, in which the cognitive demand is quite irrelevant. Results suggest that, when using an adequate scheduling of learning periods, the combination of mental and physical practice may be as effective as physical practice alone even when the task motor components are predominant. In this case, it is unlikely that improvements are due to rehearsing the cognitive elements of the task.

The few periods of ME (4 minutes on the whole) performed by MP participants can not explain the improvements shown by this group, since participants in the control group performed exactly the same amount of physical practice. The introduction of periods of watching to naturalistic videos, conversely, prevented control participants from doing any kind of mental practice about the task to be learned throughout the training period. Indeed, all participants in C group answered correctly to all the questions asked after the vision of naturalistic videos and concerning the information presented in the videos. Moreover, to total time spent during the training period, and therefore the time interval between baseline and post-training assessments, was the same for all groups. Therefore, we may speculate that the original protocol applied in the present study allowed participants to maximize the learning effect of both AO and MI.

For MP group, periods of AO were followed

by periods of physical execution of the task, so that subjects could take advantage of the previous observation in order to execute the movement more correctly. Several researchers demonstrated that observation has immediate effects on motor performance.[21, 29-32] According to Buccino *et al.*,[33] observation would generate resonant activity within the mirror neurons system and facilitate the selection of the appropriate neuronal activation pattern in the subsequent motor execution. Indeed, it has been repeatedly shown that observation enhances the ability of physical training to encode a motor memory [34-36] and that the mirror neuron system couples execution and observation also in terms of temporal coding.[37] The formation of lasting motor memory traces is, in turn, a likely prerequisite for motor skill acquisition.[7, 38]

Conversely, MI periods were always preceded by both AO and motor execution of the task, allowing subjects in the MP group to optimally practice visual and kinaesthetic imagery of the task. It seems reasonable to assume that previous periods of watching to the correct task execution and previous periods of facilitated task execution led participants to practice more accurately the third person perspective imagery and the first person perspective imagery, respectively. Indeed, a recent study by Conson *et al.*[39] demonstrated that observation of hand actions facilitates mental simulation of hand movements. In most studies showing the positive effects of MI on motor learning, kinaesthetic, rather than visual, imagery was used,[10-11, 40] but visual imagery was also found to be effective.[41] Indeed, Stinear *et al.*[42] found that only kinesthetic imagery can modulate corticomotor excitability. However, Mulder [1] proposed that visual imagery might be more useful for relearning cognitive and planning aspects of movements. Moreover, Stevens [43] demonstrated that visual and kinaesthetic MI play distinct roles in the mental representation of human movement and are cooperative processes when the movement is tied to visual coordinates in space. In any case, it should be noted that the distinction between kinaesthetic and visual imagery is somewhat artificial, and the latter may refer either to imagery of one's own movement or to imagery of another person's movement.[44] Dickstein and Deutsch,[45] therefore, concluded that the application of both visual and kinesthetic imagery appears appropriate for most individuals.

One important study limitation is that the design did not separate the effects of MI and AO. Actually, results in the MP group could be ascribed to either MI or AO periods, rather than to their combination. In future research, this topic should be addressed including groups of participants in whom the two types of mental practice are performed in isolation.

Due to the limited number of participants enrolled, no correlation analysis was conducted to study the possible association between MI ability, as assessed through the modified MIQ, and performance improvements observed after the training. Participants in MP group showed moderate to high difficulty in motor imagery, as resulted from subjective estimates on the 7-point scale used for both the MIQ and the MI training periods. Nevertheless, all MP group participants improved markedly their ability in performing the task at retention tests. The clinical utility of questionnaires aimed at measuring individual differences in imagery ability, therefore, may be questioned. Indeed, the identification of people who would profit most from MI training is a relevant question. In a sample of healthy young participants, Yágüez *et al.*[46] also did not find any correlation between motor ability improvements and imagery ability as assessed through a test comprising verbal and visual imagery tasks. Different estimates of individual imagery ability are likely to be more suitable, such as autonomic nervous system responses.[47] However, the usefulness of questionnaires in order to identify people potentially more likely to take advantage from MI, needs to be verify in far larger samples of participants.

Whether the combination of MI, AO and ME is as effective in neurologically impaired persons as it has been found to be in young healthy people remains to be evaluated. Nevertheless, we may speculate that the protocol used in the present study might allow also stroke patients to take full advantage of both mental and physical practice in order to relearn functional tasks.

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Fear of falling in stroke patients with pusher behaviour

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ABSTRACT

Aim. The aim of this descriptive cross-sectional study was to investigate the characteristics of fear of falling (FF) in stroke patients with and without pushing behaviour.

Methods. Thirty eight patients with poststroke hemiparesis and balance impairment, of whom 15 with and 23 without pusher behaviour were selected in a rehabilitation inpatient centre. All of them were asked to refer the presence and describe the side of their FF in sitting and in standing position. For each situation, the assessment was performed at rest and during passive correction of the tilted posture.

Results. No differences were found between groups in the proportions of FF "at rest" both in sitting and in standing position. Patients of PB+ group reported more frequently ipsilesional FF during passive correction of posture both in sitting and in standing position. Six patients (1 in PB+ group and 5 in PB- group) were not able to report exactly a direction of their FF and three patients (1 in PB+ group and 2 in PB- group) report also FF in ahead.

Conclusion. Despite not all patients were able to report the side of their FF, ipsilesional FF may be used as a detective sign to exclude PB in patients without severe aphasia. *(It J Physiother 2011;1:12-6)*

Key words: Posture - Fear - Accidental falls.

Patients with pusher behaviour (PB) push strongly toward the hemiplegic side with their non-affected limbs and resist attempts at passive correction of their tilted posture.[1] These characteristics are reported to be distinguishing features of PB[2].

There is growing agreement that PB reflects some misrepresentation of verticality,[3, 4] but the exact mechanism is still unclear.[5] However, postural impairment in PB seems to be due to the fact that people with PB may tend to align their body posture with a tilted perceived vertical.[2]

As an additional bedside criterion to detect PB Recently, Johannsen *et al.*[6] proposed the investigation of the pusher patients' leg-to-trunk orientation, reporting that spontaneous postural responses of the non-paretic leg during passive body tilts are specific for patients with PB. When seated upright without contact with the ground, an ipsiversive tilt of the non-paretic leg in relation to the trunk of about 9° is observed when the body were tilted for about 15° into the ipsiversive direction. The inclined leg position is maintained throughout the entire tilt cycle. This reaction was not observed in non-brain-damaged subjects, in patients with acute unilateral vestibular dysfunction, or in patients with stroke without PB and vestibular dysfunction.

Clinical observation suggest that patients with PB report fear of falling (FF) toward the unaffected, rather than the paretic side, in accordance with one of the first report about the syndrome.[1] Recently, Shepherd and Carr suggested that the behavioural development may be a natural adaptive response to the posture correction that have the potential to increase the fear of falling and

Table I.—*Subjects' characteristics (N.=38).*

	PB+	PB-	P
Number	15	23	
Gender (F/M)	5/10	14/9	NS
Age (M ± SD)	75.9±8.7	71.1±11.6	NS
Hemisphere of stroke (R/L)	14/9	9/6	NS
Stroke type (I/H)	12/3	15/8	NS
Time from stroke onset (days) (M±DS)	12.4±3.3	13.2±4.0	NS
Neglect	5	8	NS
Aphasia	5	6	NS
Fugl-Mayer (M±DS)	107.6±20.6	106.7±32.7	NS
Barthel Index (M±DS)	28.3±11.2	25.6±8.2	NS
SCP	3.2±1.4	0.9±0.6	P<0.001

M: mean; SD: standard deviation; NS: not significant; M: male; F: female; R: right; L: left; I: ischemic; E: hemorrhagic; SCP: Scale for Contraversive Pushing.

provoke defensive pushing.[7] FF characteristics could be a further distinctive feature characterizing PB, but this aspect was never systematically investigated. We hypothesized that identifying features of FF that are specific in patient with PB might provide further insights about the nature of the verticality misperception in these patients. In addition, this could provide a simple adjunctive tool for detecting the syndrome.

The aim of this study was to investigate the characteristics of FF in stroke patients with and without PB.

Materials and methods

Subjects

A sample of 38 patients with hemiparesis due to first stroke and admitted to a city rehabilitation department was selected to be assessed.

They all met the following inclusion criteria: (a) first stroke; (b) monolateral cerebrovascular accident supported by computer tomography scans or magnetic resonance imaging; (c) recent stroke (occurred within less than 30 days); (d) no additional orthopaedic or neurological disabling deficits; (e) no severe cognitive impairments (Pfeiffer's Short Portable Mental Status Questionnaire≤7); (f) no severe aphasia, such as impossibility to assess fear of falling (Goodglass and Kaplan Scale level 2). Patients with bilateral lesions by CT or MRI were excluded. A neurologist made the stroke diagnosis.

An additional inclusion criterion was the presence of balance impairment, in both sitting and standing position with or without definite PB. Subject characteristics are summarized in Table I.

Participants gave their written informed consent for collection, storage, and use of personal data.

Assessment

At admission in rehabilitation department clinical and demographic characteristics were recorded. Moreover, functional status was assessed by the Barthel Index (BI) [8] motor impairment by the Fugl-Meyer Scale (FM).[9] The presence of visual neglect was assessed using the Albert test,[10] while the Goodglass and Kaplan Scale,[11] a five-level hierarchic scale of seriousness of aphasia, was used to detect the presence of speech impairments.

Each patient was assessed by a trained physiotherapist with the Scale for Contraversive Pushing (SCP).[3]

The SCP comprises 3 sections, each assessing a particular feature of the syndrome, namely, the symmetry of spontaneous body posture (section A), the use of non affected extremities (leg or arm) to push by abduction and extension thrust (section B), and the resistance to passive correction of the tilted posture (section C). For each item, the score ranges from 0 to 1. Because each feature is examined in both sitting and standing positions, the maximum score in each section is 2. Recently, the authors completed and integrated instructions and task definitions for SCP administration and scoring.[12]

The SCP has been found to have an high interobserver reliability for both subscores and total score.[13] The scale also showed excellent internal consistency [13] and construct validity.[14]

Subjects were differentiated into two groups according to the presence or absence of PB (PB+ group and PB– group, respectively), on the basis of the SCP cut-off score suggested by Baccini *et*

al.,[13] *i.e.* a score greater than 0 in each of the three sections of the scale. This criterion was preferred to the original one suggested by Karnath [3] since it was shown to lead to the most accurate diagnosis in a large sample of unselected stroke patients.[14]

All patients gave their written informed consent.

Procedure

All patients were asked to refer the presence and describe the side of their fear of falling in the following different situations:

1) in sitting position, at the bedside with legs hanging free and feet off the ground, without a support for their back;

2) in standing position, with a physiotherapist on the patients' contralesional side. Patients were supported by the physiotherapist when needed, in order to prevent falls.

For each situation, the assessment was performed at rest, and then the experimenter applied a sideways tilting motion of the subjects' trunk or body to the side opposite to the lateropulsion, left or right. The subjects were instructed that they would be moved sideways and that they should not resist this passive movement. For each patient, the passive correction of the tilted body posture was performed in the same place and by the same examiner, a physiotherapist with experience in stroke and PB rehabilitation.

When patients reported FF this was recorded for each situation, together with the side of FF.

Statistical analysis

The χ^2 test for comparisons of proportions and the t-test for mean values were used to compare the demographic and clinical characteristics of patients in PB+ and PB- groups.

The χ^2 test for comparisons of proportions was used to compare patients with PB and patients without PB in terms of FF "at rest" and FF during passive correction of posture both in sitting and in standing position, as well as in terms of side of FF.

Data analyses were performed using SPSS 12.0 for Windows.

Table II.—*Results of reported FF and of SCP diagnosis.*

	PB+	PB-
Reported FF towards the ipsilesional direction	13	0
Reported FF towards other directions than ipsilesional	2	23

FF: fear of falling; PB: pusher behaviour; SCP: Scale for Contraversive Pushing.

Results

Table I compares gender and age distribution and patients' general clinical characteristics, including side and type of stroke, time from stroke onset, presence of neglect and aphasia, admission scores of BI, FM and SCP. No significant differences in any of these parameters were found between the two groups, except for SCP scores.

Fifteen patients were diagnosed as having PB. No differences were found between groups in the proportions of FF "at rest" both in sitting and in standing position (χ^2=0.369, P=0.543 and χ^2=2.916, P=0.877, respectively). Patients of PB+ group report more frequently FF during passive correction of posture both in sitting and in standing position (χ^2=17.623, P<0.001 and χ^2=6.609, P=0.010, respectively). Six patients (1 in PB+ group and 5 in PB- group) were not able to report exactly a direction of their FF and three patients (1 in PB+ group and 2 in PB- group) report also FF in ahead. Fourteen patients of PB group reported ipsilesional FF, and 18 of the PB- group report contralesional FF (χ^2=32.000, P<0.001). Five patients, all in the PB+ group, needed physical support by the physiotherapist because a high risk of fall.

Table II summarizes the results of reported side of FF, which was assumed to be related to the presence of PB, and of SCP diagnosis. Reported FF sensitivity, was 86.7% (13/15), specificity was 100.0% (23/23) and the predictive value of FF towards the ipsilesional side was equal to 100.0% (13/13).

Discussion

PB has characteristics which distinguish it from other neurological disturbances of balance [2] and

which seems to be a consequence of an erroneous reference of verticality.[15]

The pathogenesis of contraversive pushing is still unclear. For example, Karnath *et al.*[16] and Pérennou *et al.*[4] report that patients with PB have an unimpaired visual vertical (VV). The VV (with a haptic component) and the subjective straight ahead (SSA) was found to be tilted to the side of the lesion in patients with neglect without PB and tilted to the contralesional side in patients with neglect and PB.[17, 18] In terms of postural vertical (PV), Karnath *et al.*[2] found that patients with PB subjectively perceive their body as oriented upright when it is tilted an average of 18° to the ipsilesional side.

Recently, Perennou *et al.*[15] in a large investigation, show that patients with PB showed a transmodal tilt (PV+ VV + Haptic Vertcal) of verticality perception and a severe postural vertical tilt. Interesting, patients with PB displayed the largest contralesional tilts.

Some authors found a negative correlation between the SVV and the SPV with a significant positive correlation between the tilt of the SVV and the head posture, which was turned and shifted laterally towards the ipsilesional side.[17] The authors suggest that the "pseudo" correct SVV in the PB patients may be the result of a ipsilesional tilt of the head as a result of a contralesional shift of their body orientation. This may imply a relationship between the axis of the head, trunk and head–trunk unit.

Our results support the idea that pusher has a contralesional bias in the perception of verticality. In fact, patients with PB has always FF when their posture were correct towards the non-hemiplegic side till the real vertical.

Probably, when the patients' body is moved to a objectively upright position, they feel them laterally unstable due to the fact that their subjective vertical is contralesional tilted. Pushing the body to the opposite (contralesional) side might constitute a reaction to this experience, as suggested by Shepherd and Carr.[7] Than our results seems to show that objective vertical misperception, postural reactions and FF are expressions of the same problem.

With respect to clinical practice, the present findings show that the investigation of the patients' orientation of FF might serve as a simple additional bedside tool to exclude PB in acute stroke patients. However, because selection criteria of the study might exclude patients with PB and severe aphasia, the direction of FF cannot be used in patients with severe aphasia.

In addition, results of this investigation support the choice of a facilitation of patient's active correction of the posture rather than passive correction,[1, 20-22] and the care to perform the exercises without evoking fear during physiotherapy.

Some limitations of the study have to be taken into account. Some patients needed physical support and this could have introduced a bias. Moreover, other six patients were not able to report exactly a side of their FF, reducing the sensitivity of the reported FF as a clinical tool for PB detection. Despite both specificity and predictive value of ipsilesional FF were 100.0%, showing that all patients who were diagnosed as having PB reported the ipsilesional side of their FF, the sample selected in the present study were not representative of the general stroke population, since only patients with balance impairment were included. The incidence of PB in our participants was much higher compared to the incidence in the literature [23, 24] and the rate of true-positives should be expected to be much higher than that in an unselected stroke population.

Moreover, no information are available about reliability of the procedure and in the present study only one examination were performed for each patient. For these reasons, results on sensitivity and specificity should be considered with caution. Finally, FF was considered as a dichotomous value, with a potential risk of loss of useful information about particular aspects of the subjective perception of the FF.

Conclusions

In conclusion, FF has distinctive characteristics in patients with PB, which are in accordance with a contrelesional bias in the perception of verticality. These finding could serve as an additional bedside tool to exclude PB in acute and subacute stroke patients.

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REVIEW ARTICLE

Efficacy of non-invasive ventilation for cardiothoracic surgical patients: a systematic review

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ABSTRACT

Aim. Patients undergoing thoracotomy or heart surgery are at risk of developing postoperative pulmonary complications (PPC) such as pneumonia, arterial hypoxemia, need of re-intubation, atelectasis and acute respiratory failure (ARF). Non-invasive ventilation (NIV) may be an important tool to prevent or to treat ARF by reducing the work of breathing and improving alveolar recruitment in order to promote a better recovery of patients and reducing the length of stay (LOS) in the hospital or in intensive care unit. The objective of this review was to assess the efficacy of NIV in treatment of patients recovering from cardiothoracic surgery.

Methods. Electronic databases were searched for randomised controlled trials (RCTs) comparing NIV with other respiratory techniques in adult who underwent heart or thoracic surgery. The primary and secondary outcomes were LOS and incidence of PPC respectively.

Results. Thirteen RCTs are included in this review, most of which are of low quality. Twelve RCTs used prophylactic NIV and one a curative NIV.

Conclusion. Prophylactic NIV seems to be effective in reducing LOS in patients at high risk of developing PPC and it can decrease the incidence of PPC in low risk patients. Curative NIV seems to be effective in reducing the rate of intubation and the mortality in patients presenting ARF. Further studies are necessary to better define a protocol to improve efficacy and preserving safety. *(It J Physiother 2011;1:17-26)*

Key words: Physical therapy modalities - Postoperative care - Review literature as topic.

Patients undergoing thoracotomy or heart surgery are at high risk of developing postoperative pulmonary complications (PPC).[1] The PPC are defined as "pulmonary abnormalities that produce an identifiable clinically significant disease or dysfunction that adversely affect the clinical course".[2] These pulmonary disorders represent the major cause of postoperative mortality.[3] Perioperative factors, such as general anesthesia, pulmonary modifications after extracorporeal circulation and postoperative pain, are factors that contribute with the occurrence of PPC.[4]

Anaesthetic reduces the muscle tone that increases lung retractile forces. Such phenomenon contributes to atelectasis development and rises risk of pneumonia. Extracorporeal circulation or transfusion may lead to acute lung injury further affecting gas exchanges. Surgery disrupts thoracic and diaphragmatic muscles forces, reduces phrenic output, and induces pain. These early and transitory modifications of respiratory function may lead to acute respiratory failure (ARF) that affects the "pump function" (respiratory muscles) and the "exchange function" (lungs).[5] ARF may need endotracheal intubation that extends the intensive care unit (ICU) stay, raises prevalence of infections and mortality, prolongs hospital length of stay (LOS) and increases costs.[6-8]

The incidence of PPC ranges between 20% to 40% for the thoracic and abdominal surgery.[9] Being older than 70 years old, smoking history,

chronic obstructive pulmonary disease, obesity and previous reduction of pulmonary function are considered risk factors for the development of PPC.[10]

So far, respiratory physiotherapy has long been considered an essential aspect of pre- and postoperative treatment of patients undergoing thoracic surgery [11] with the objective to restore and maintain lung function, prevent the onset of PPC and ARF, develope and promote a better recovery of patients reducing the hospitalization. Commonly used conventional respiratory care (CRC) methods are the incentive spirometry (IS), the positive expiratory airways pressure, recruitment maneuvers and change of position. CRC has not yet provided efficacy in postoperative treatment.[6, 12] More recently non-invasive ventilation (NIV) have the main physiological effect to promote pulmonary re-expansion.

Continuous positive airways pressure (CPAP) and pressure support (PS) are the most used NIV methods. CPAP delivers constant positive airways pressure during the whole cycle of breathing. In PS ventilation the patient's inspiratory effort triggers the ventilator to provide a variable flow of gas that increases until airway pressure reaches a selected level.[13] The most used interfaces for NIV applications consist of facial mask, nasal mask and helmet.

NIV may be an important tool to prevent or to treat ARF (prophylactic or curative treatment) [13] because by reducing the work of breathing and improving alveolar recruitment it is possible to restore the respiratory function affected after surgery. The efficacy of NIV in the treatment of ARF has been largely demonstrated in patients with COPD, cardiogenic pulmonary edema and in immunocompromised patients, while its role after cardiothoracic surgery is still disputed.[14]

The objective of this review was to assess the efficacy of NIV in the reduction of LOS, prevention and treatment of PPC and ARF in patients recovering from cardiothoracic surgery.

Materials and methods

Inclusion/exclusion criteria

Randomised controlled trials (RCTs) that compare NIV with other techniques for prophylaxis or treatment of PPC in adults who undergone heart or thoracic surgery.

Outcomes

Primary outcome was length of stay (LOS) in ICU or in the hospital structure.

Secondary outcomes are the incidence of PPC (pneumonia, severe hypoxemia and need of re-intubation), presence of atelectasis and gas exchange efficiency.

Search strategy

Published studies of significant relevance were identified using an any language electronic search strategy, limited to RCTs, for MEDLINE and adapted for EMBASE, CINAHL and the Physiotherapy Evidence Database (PEDro) up to December 2010. The search terms used to find all trials registers and databases are: thoracotomy; thoracic surgical procedures; pneumonectomy; pulmonary surgical procedures; aortic aneurysm; thoracic; blood vessel prosthesis implantation; vascular surgical procedures; myocardial reperfusion; coronary artery bypass; myocardial revascularization; heart valve prosthesis implantation; heart bypass; right; cardiovascular surgical procedures; circulatory arrest, deep hypothermia induced; heart transplantation, pericardiectomy, CABG; cardiac surgery; cardiopulmonary bypass; open heart surgery; aortic valve; mitral valve; "tricuspid valve" OR "pulmonary valve" OR "pulmonary surgery" OR "thoracic surgery" OR "aortic surgery"; thoracic aortic surgery; coronary artery bypass graft*; aortocoronary bypass surgery; coronary surgery; heart valve prosthesis; heart surgery; cardiac surgery; high-frequency ventilation; positive-pressure respiration; respiration, artificial; oxygen inhalation therapy; mechanical ventilation; recruitment maneuver; NIV; CPAP; PEEP; mechanical ventilation; non-invasive mechanical ventilation; recruitment maneuver*; vital capacity maneuver*; postoperative complications; respiratory insufficiency; hospitalization; pulmonary atelectasis; blood gas analysis; oximetry; postoperative pulmonary complications; pulmonary complications; atelectasis; length of stay.

An unsystematic handsearching, web searching and references screening was added to the electronic search. Reference lists of papers in-

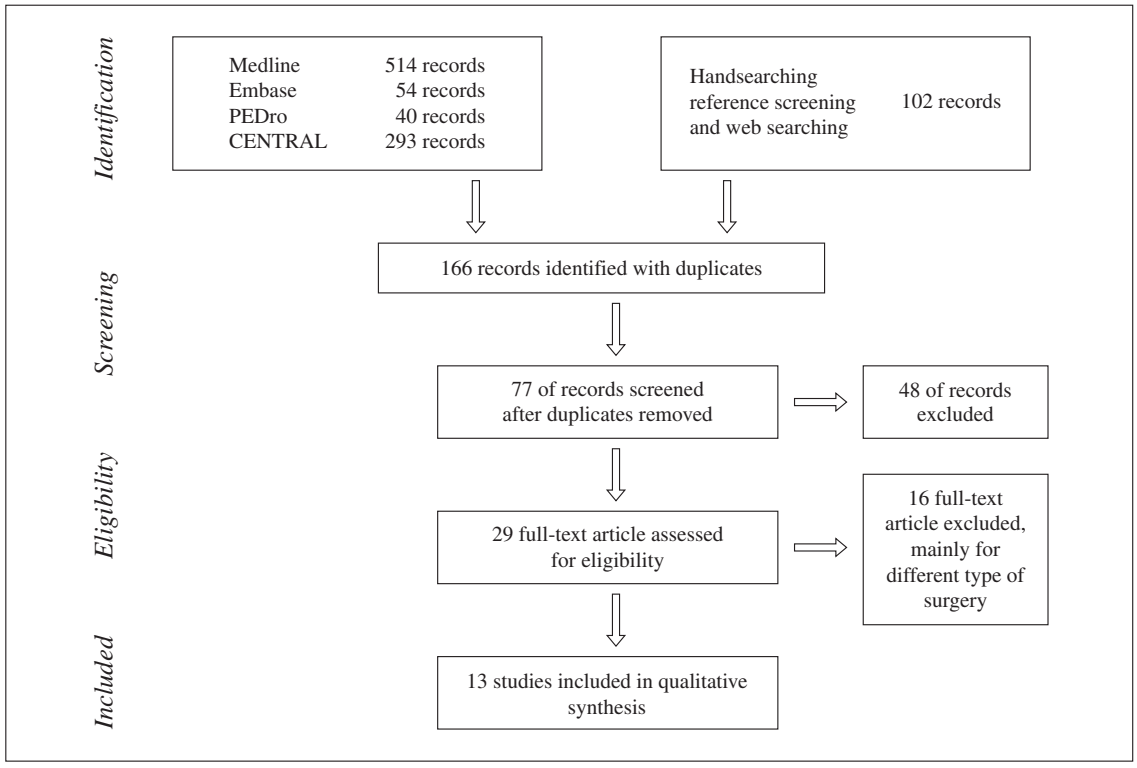

Figure 1.—Flow of information through the different phases of

cluded in the review were searched without giving new relevant records (Figure 1).

Data selection and analysis

Retrieved references were screened by reading titles without removing duplicates and added to records obtained from unsystematic handsearching, web searching and references screening. A second screening was obtained by reading abstracts after removing duplicates. Two reviewers independently filtered search results for eligibility, assessed methodological quality and extracted data in an extraction form.

The studies' quality was assessed using the Cochrane Handbook for Systematic Reviews of Interventions.[15]

Results

Thirteen RCTs were included. Twelve studies used a prophylactic NIV to prevent ARF, one study used a curative NIV for treatment of ARF.

Table I.—*Participants characteristics.*

Study	Participants characteristics	
	Type of surgery	Age range (Years)
Stock 1984 [16]	Cardiac	30-76*
Pinilla 1990 [17]	Cardiac	45-73*
Ingwersen 1993 [21]	Cardiac/Pulmonary	NR
Jousela 1994 [9]	Cardiac	31-70
Aguilò 1997 [25]	Pulmonary	41-62*
Matte 2000 [18]	Cardiac	45-82*
Auriant 2001 [22]	Pulmonary	40-80*
Pasquina 2004 [7]	Cardiac	40-90*
Kindgen-Milles 1995 [3]	Toracoabdominal	59-75*
Perrin 2007 [23]	Pulmonary	57-69*
Celebi 2008 [19]	Cardiac	34*- 65
Lopes 2008 [20]	Cardiac	20-80
Zarbock 2009 [8]	Cardiac	58-66*

NR: not reported; * Estimated from SD.

Eight studies included heart surgery patients [7-9, 16-20] (four coronary bypass surgery patients and four unspecified cardiac surgery patients), four

Table II.—*Characteristics of studies.*

Study	Type of intervention	Characteristics of treatment			
		Type of NIV and Pressure (cm H20)		Mean time of treatment (hours/day)	Type of mask
		CPAP	PS (Peep+PS)		
Stock 1984 [16]	CPAP *vs.* CRC	5-7.5		3 (1 h cycles) §	Face
Pinilla 1990 [17]	CPAP *vs.* CRC	5-7.5		12	Face alternate nose
Ingwersen 1993 [21]	CPAP *vs.* CRC	15		MM	Face
Jousela 1994 [9]	CPAP *vs.* CRC	10		8	Face
Aguilò 1997 [25]	PS *vs.* CRC		5±10	1	Nasal
Matte 2000 [18]	CPAP *vs.* PS	5	4-5±8-12	8 (1 h cycles)	Face
Auriant 2001 [22]	PS *vs.* CRC		4±12	14 (2 h cycles) §	Nasal
Pasquina 2004 [7]	CPAP *vs.* PS	5	4-5±8-12	2 (0.5 h cycles)	Face
Kindgen-Milles 1995 [3]	CPAP *vs.* CRC	10		12 to 24	Nasal
Perrin 2007 [23]	PS *vs.* CRC		5±10	5 (1 h cycles) *§	Face
Celebi 2008 [19]	PS *vs.* CRC		5±10	4 (1 h cycles)	Face
Lopes 2008 [20]	PS *vs.* CRC		5±8-12	0.5	Face
Zarbock 2009 [8]	CPAP *vs.* CRC	10		9	Nasal

CPAP: continuous airways positive pressure, PS: pressure support, CRC: conventional respiratory care; MM:5 minutes/waking horus; §: for 2 or 3 days; *:following seven preoperative days.

studies handled thoracic surgery (three pulmonary resection patients, one replacement surgery of thoraco-abdominal aorta patients) and one study included both kind of patients.[21] All studies excluded patients aged <18 years or unable to sign informed consent (Table I).

Intervention

The interventions utilized in the included studies are detailed in Table II.

The mainly used interface for application of NIV is the face mask (eight studies of 13).

Six RCTs compare the use of CPAP *vs.* CRC, four after cardiac surgery,[8, 9, 16, 17] one after thoracoabdominal surgery [3] and one with patients belonging from both conditions.[21]

Five RCTs compare the use of PS *vs.* CRC, two after cardiac surgery,[19, 20] and three after pulmonary surgery.[22, 23-25]

Two RCTs compare the use of CPAP *vs.* PS on cardiac surgery.[7, 18]

Of the eight studies using CPAP, two used a pressure of 5 cmH_2O,[7, 18] one used a pressure of 7.5 cmH_2O,[16] one a pressure either of 5 or 7.5 cmH_2O [17] and in the remaining studies a pressure of 10 cmH_2O was used except in one study which 15 cmH_2O was used.[21]

In the studies that implied PS was used an inspiratory pressure of 8-12 cmH_2O and an expiratory pressure (PEEP) of 4-5 cmH_2O.

Prophylactic NIV was applied for 0.5 to one hour in two studies immediately after extubation in order to verify its short term effects; two [18, 19] during the first postoperative day with intermittent cycles of one hour every four-eight hours; four [3, 8, 9, 17] continuously from 8 to 12-24 hours per day. In the study by Perrin *et al.*[23] prophylactic NIV was applied seven days before the surgery up to three postoperative days with one hour of NIV for five cycles per day.

Two studies compared CPAP to PS; in the work of Pasquina *et al.*[7] patients undergone an half hour therapy every six hours while in the work of Matte *et al.*[18] patients underwent an hour therapy every three hours.

Curative NIV was applied for a mean of 14 h per day for two days[22].

Table III.—*Reported outcomes.*

Study	Type of intervention	ARF	Main reported outcome					
			Leght of stay	Postoperative pulmonary complications (PPC)			Atelectasis	Gases exchange
				Arterial hypoxemia	Polmonitis	Reintubation		
Stock 1984 [16]	CPAP *vs.* CRC	P			X		X	X
Pinilla 1990 [17]	CPAP *vs.* CRC	P	X		X		X	X
Ingwersen 1993 [21]	CPAP *vs.* CRC	P					X	X
Jousela 1994 [9]	CPAP *vs.* CRC	P	X	X	X		X	X
Aguilò 1997 [25]	PS *vs.* CRC	P						X
Matte 2000 [18]	CPAP *vs.* PS	P	X				X	X
Auriant 2001 [22]	PS *vs.* CRC	C	X			X		
Pasquina 2004 [7]	CPAP *vs.* PS	P	X				X	X
Kindgen-Milles 1995 [3]	CPAP *vs.* CRC	P	X	X	X	X	X	X
Perrin 2007 [23]	PS *vs.* CRC	P	X				X	X
Celebi 2008 [19]	PS *vs.* CRC	P					X	X
Lopes 2008 [20]	PS *vs.* CRC	P						X
Zarbock 2009 [8]	CPAP *vs.* CRC	P	X	X	X	X		X

CPAP: continuous airways positive pressure; PS: pressure support; CRC: conventional respiratory care. ARF: acute respiratory failure; P: profilactic; C: curative.

Outcomes

Eight studies assessed the LOS, three of thoracic surgery patients [3, 22, 23] and five [7-9, 17, 18] of cardiac surgery patients. The study of Matte *et al.*[18] considered the LOS only in ICU.

Five works [3, 8, 9, 16, 17] assessed the incidence of pneumonia. In one study, pneumonia was diagnosed by body temperature level and white blood cells count.[9] Another study [16] made a diagnosis of pneumonia when patients showed two or more of three signs: changes in amount or color of sputum, body temperature >38.5 °C in two different occasions and presence of infiltrated at X-ray. Two studies [3, 8] followed the guidelines of Garner *et al.*[24] the diagnosis and the last study [17] assessed characteristics of sputum and white blood cells count.

Three works [3, 8, 22] assessed the incidence of reintubation.

All works except one [22] analyzed gas exchange (partial pressure of oxygen in arterial blood on the percentage of oxygen in a gas mixture ratio - PaO_2/FiO_2 - or partial pressure of oxygen in arterial blood - PaO_2 - and partial pressure of carbon dioxide in the arterial blood - $PaCO_2$). One author [25] also reported the pressure gradient of oxygen from alveolar to arterial $P(A\text{-}a)O_2$.

Nine studies [3, 7, 9, 16-19, 21, 23] assessed the presence of atelectasis by chest X-ray performed by radiologists blinded to treatment condition, three of whom [19, 21] quantified the degree of atelectasis with a numerical scale (Table III).

Risk of bias

Randomization was described and appropriate in seven studies.[3, 7, 8, 16, 19, 20, 23] Two of these were three-armed,[18, 21] in both studies it is not clearly stated how many randomized patients were placed per group. The allocation concealment was described and appropriate in five RCTs.[7-9, 19, 23]

The outcome assessor was blinded in eight studies mainly for X-ray assessment of atelectasis. In two studies [3, 8] the clinicians who decided the discharges from the ICU were blinded to the patients' group.

Table IV.—*Methodological quality of included studies.*

Study	Sample size	Description of randomisation	Allocation concealment	Blinded assessor	Withdrowals	Analysis
Stock 1984 [16]	38	Yes	Unclear	Yes	NR	NR
Pinilla 1990 [17]	77	NR	Unclear	No	25%	P
Ingwersen 1993 [21]	160	NR	Unclear	Yes	10%	P
Jousela 1994 [9]	30	NR	Adequate	No	NR	NR
Aguilò 1997 [25]	20	NR	Unclear	No	5%	P
Matte 2000 [18]	96	NR	Unclear	Yes	16%	P
Auriant 2001 [22]	48	NR	Unclear	No	2%	I
Pasquina 2004 [7]	150	Yes	Adequate	Yes	10%	I
Kindgen-Milles 1995 [3]	50	Yes	Unclear	Yes	4%	I
Perrin 2007 [23]	39	Yes	Adequate	Yes	18%	P
Celebi 2008 [19]	100	Yes	Adequate	Yes	NR	NR
Lopes 2008 [20]	100	Yes	Unclear	No	NR	NR
Zarbock 2009 [8]	468	Yes	Adequate	Yes	6%	I

For the allocation concealment the therm "adequate" is used when the method of allocation is clearly described while "unclear" when the authors do not report any allocation concealment approach. For blinding assessor "Yes" indicates the blind condition for at least one outcome (generally atelectasis); for Analisys P indicates an analysis "per protocol", I "per intention to treat" and NR: not reported.

Four studies did not report patients' drop-outs,[9, 16, 19, 21] three studies [3, 7, 22] performed an intention-to-treat analysis of patients that discontinued the study (always less than 10%) and five studies performed a per-protocol analysis even with 25% of randomized patient lost to follow-up.[17] In the study of Zarbock *et al*.[3] 500 patients were randomized into groups and 32 patients were excluded before starting treatment because they did not meet the inclusion criteria (mainly for re-intervention, heart failure and duration of intubation >18 hours). Studies always reported information about treatment withdrawal reasons (Table IV).

Primary outcome - Length of stay

Prophylactic NIV

Five studies, four considering CPAP [3, 8, 9, 17] and one considering PS,[23] on 664 patients measured LOS of patients after NIV treatment *versus* CRC treatment. Three of them dealt with cardiosurgery patients,[8, 9, 17] one with pulmonary surgery patients [23] and one with thoracoabdominal surgery patients.[3] The majority of patients who received CPAP used a 10 cm H_2O pressure, while PS was given with a 5 cm H_2O Peep and a 10 cm H_2O pressure support. Only two studies [3, 23] including 89 patients showed a statistically significant reduction of LOS in the hospital but not in the ICU.

Two studies,[7, 18] with 212 patients recruited, measured LOS of patients after CPAP treatment versus PS treatment. None of these studies found a significative difference in the LOS in ICU.

Curative NIV

One study [22] on 48 patients with ARF did not show an effect of PS in reducing LOS.

Secondary outcomes – PPC

Prophylactic NIV

Five studies [3, 8, 9, 16, 17] on 663 patients assessed the effect of NIV on PPC as defined in this review. Only two studies [3, 8] including 518 patients showed statistically significant differences in reducing arterial hypoxemia, pneumonia and incidence of re-intubation.

Curative NIV

One study on 48 patients,[22] showed a statistically significant reduction in re-intubation and an improvement of a non-severe arterial hypoxemia (PaO_2/FiO_2 values near 100) after two hours of treatment.

Gas exchanges and atelectasis

Arterial oxygenation shows a tendency to improve after treatment with NIV, whether no differences are detected in atelectasis formation. Concerning the efficacy of CPAP versus PS one study [7] reported better results of PS *versus* CPAP in the improvement of atelectasis during the first two postoperative days but not in the gas exchanges and one study did not find any statistical difference.[18]

Discussion

Thirteen RCTs on the efficacy of NIV in the treatment of cardiothoracic surgery patients have been included in this review. On average the quality of trials was low. Only a half reported on an appropriate method of randomization and a minority on allocation concealment, although bad reporting may not mean bad practice. The majority of trials attempted to blind the observers. In only a few trials was the follow-up of patients adequately reported and data analyzed according intention-to-treat.

Twelve on 13 used the NIV as a prophylaxis of ARF, one work evaluate the curative effect.[22]

LOS, in ICU or hospital, was chosen to be the primary outcome as it could turn out to be an indicator of patient clinical history. PPC (severe arterial hypoxemia -PaO_2/FiO_2 <100-, pneumonia, and need to re-intubation) defined as pulmonary abnormalities that produce an identifiable clinically significant disease or dysfunction that can potentially adverse the clinical course were analyzed as secondary outcome.

The incidence of atelectasis was also considered, because it is often the main cause of an outbreak of PPC, as gas exchanges' quality was also considered because it can be an indicator of NIV pulmonary effectiveness.

Prophylactic NIV

Of the eight studies [3, 7, 8, 17, 18, 22, 23] analyzing the LOS, two showed a statistically significant difference in LOS in the hospital between groups.[3, 22] Both studies included patients at high risk of developing PPC than those in other studies. The study of Perrin *et al.*[23] was on 39 patients who underwent lung resection. Subjects with obstructive airways syndrome were enrolled. The study of Kindgen-Milles *et al.*[3] included 50 patients after thoracoabdominal aortic surgery which is known as one of the procedures with the highest risk of PPC.[26] In fact, the control group in this study showed a rapid and considerable development of postoperative hypoxemia reaching a PaO_2/FiO_2 <200 four hour after extubation. On the other hand the study of Zarbock *et al.*,[3] which have the widest sample, excluded patients with chronic respiratory disease and postoperative heart failure.

The dosage of NIV is another factor that could have influenced the outcomes. In the study of Perrin *et al.*[23] the subjects have been treated for seven days before surgery and up to three postoperative days while in all other studies patients were treated only during the first postoperative day. In the study of Kindgen-Milles *et al.*[3] the patients received CPAP at 10 H_2O for 12 to 24 h while in all other study the participants were treated from 2-4 to 12 h.

Some authors [23] argued that considering the LOS as an indicator of outcome on the effect of NIV could be controversial as it should be recognized that the length of stay in hospital (ICU or other wards) can also be caused by factors that are independent from treatment and patient's needs, such as the unavailability of beds for new departments or rehabilitation units.[23, 27] Nevertheless, the LOS is a method often used for directly assessing complications occurring after surgery.[28-31]

The results on the effectiveness of NIV as prophylaxis of PPC and their relative impact on the clinical course, showed that patients "at low risk", using appropriate pressure and applying the protocol for at least nine hours in the first postoperative day, could have positive effect on reduction of PPC but no effect on LOS. Con-

cerning PPC only two studies [3, 8] of five reported a significant reduction with profilactic NIV both utilizing CPAP at a pressure of 10cmH_2O for 12-24 h on thoracoabdominal [3] or cardiac surgery patients.[8]

The reason why the other studies did not find significant result may depend on several factors: 1) the small samples size; 2) the different definition of PPC: in the study of Zarbock *et al.* and in that of Kingel-Milles *et al.* the PPC were calculated as the sum of patients developing several pulmonary dysfunctions (reintubations, pneumonia, PaO_2/FiO_2 <100), thus leading to an increase of the PPC's incidence; 3) the different dosage: Stock *et al.*[16] applied the NIV only 2h/die; 4) pressures used: Stock *et al.*[16] used 7.5 cmH_2O and Pinilla *et al.*[17] used 5 and 7.5 cmH_2O.

Blood gas exchanges and pulmonary atelectasis were considered secondary outcomes despite they are primary in the majority of included studies. Only one study [19] reported a statistically significant difference in the prevention of atelectasis in favor of NIV, while other studies showed a positive trend in the treatment groups. The incidence of atelectasis seemed to be higher in the second post-operative day. This led to the hypothesis that prolonged treatment may be more effective in atelectasis' prevention. A prolonged treatment beyond the first postoperative day could be applied, after the discharge from the ICU, in the surgical wards. Only one pilot study evaluated NIV application outside the ICU, in the cardiac surgery ward, to treat mild to moderate late ARF reporting an acceptable feasibility and safety of the NIV treatment.[31] Results from this study, taking place in a hospital with a large experience in NIV treatments in ordinary wards,[32] are not generalizable: safety and efficacy can be severely impaired outside the ICU. However, considering the limited availability of beds in the ICU, the opportunity to apply NIV in surgical wards in selected patients should be (but cautiously) evaluated.

The gas exchange improvement does not seem to coincide with a reduction in atelectasis, this is probably due to the diagnostic method: blood gas analysis is more reliable and do not undergo to the examiner judgments as for X-ray. A reliable incidence of atelectasis would be best observed by CT scan.

Regarding the comparison of CPAP versus PS a well conducted study showed a better effectiveness of PS in the improvements of atelectsis but not in the gas exchanges. However, it is important to underline that the CPAP was set at only 5 cmH_2O while the PS group utilized the same level of expiratory pressure plus the pressure support leading to a higher positive pressure used in this group.

Curative NIV

The results of the study of Auriant *et al.*[22] showed that in case of postoperative ARF the use of NIV for many hours a day may prevent reintubation and mortality.

Observational [33-36] and retrospective [37] studies on the use of NIV to treat postoperative AFR reported high rate of success in avoiding intubation from 76% to 86% after cardiac [36] or thoracic surgery.[35-37] The presence of pneumonia, cardiac comorbidity and no initial response to treatment are reported to be predictors of NIV failure [34-36] and must be taken into account to improve the safety of NIV application during postoperative ARF.

Conclusions

So far NIV has been applied as a preventive or a curative tool after cardiac and thoracic surgery in a limited number of studies. Initial results seems quite positive. Prophylactic NIV appears to be effective in reducing LOS in cardiothoracic surgical patients considered at risk of developing PPC. In low risk patients prophylactic NIV delivered at least 6-9 hours in the first postoperative day can decrease the incidence of PPC and the postoperative hypoxemia but not the late development of atelectasis. CPAP and NIV seem to be equally effective in improving postoperative hypoxemia and atelectasis.

In case of postoperative ARF, NIV seems to be effective in reducing the rate of intubation and the mortality. An overall estimation of treatment effect could produce a more reliable information on the use of this technique. Considering heterogeneity of studies about the pathology and clinical condition of included patients, reported data

seem not to be sufficient for conducting a meta-analysis on primary outcome. Further studies are necessary to better define the finest protocols to improve efficacy while preserving safety.

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REVIEW ARTICLE

Efficacy studies in neurological physiotherapy: is a new point of view possible?

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ABSTRACT

The aim of this paper was to describe neurological physiotherapy literature and to analyze whether similar treatments are used to obtain the same objectives in patients with different diseases. MEDLINE and EMBASE databases were consulted until December 2007. All types of studies on the effectiveness of physiotherapy in adults with a central nervous system lesion were included. The articles selected were catalogued with respect to title, author, journal, year of publication, type of study and pathology. In order to verify whether the same treatments were used for the same objectives in different pathologies, controlled trials concerning the most frequently studied neurological diseases were classified according to treatment and objective. The number of articles and journals in which the articles were published has increased over years, reaching a total of 3 065 articles published in 589 journals. The most studied diseases are stroke (1 304 articles), spinal cord injuries (SCI, 644), Parkinson's disease (PD, 230) and multiple sclerosis (MS, 175). From the classification of the controlled trials on these four diseases, it emerges that a specific treatment has been frequently applied to obtain the same outcome in more than one disease (69 times for a total of 549 articles). The literature shows an increasing trend towards rehabilitation treatments based on motor deficit rather than on etiology. These data may favour a clinical approach based primarily on motor signs not strictly related to pathology, achieving a stronger association between evidence-based medicine (EBM) and evidence-based practice (EBP). *(It J Physiother 2011;1:27-35)*

Key words: Central nervous system - Rehabilitation - Motor skills.

The relevance of evidence-based medicine (EBM) is increasing over years. EBM quantifies the evidence data from the scientific literature's according to a qualitative hierarchy where randomized controlled trials (RCT) are placed at the top.[1, 2]

EBM is also gaining an important role in neurological physiotherapy,[2-5] where there is a growing interest in RCTs, compared to other kinds of studies.

However, the design of RCTs in physiotherapy research is often complicated due to some characteristic features of this discipline. Elaborated types of treatments and outcomes are frequently required.[6] Moreover another difficulty is represented by the large costs of human and financial resources needed to conduct a RCT with an adequate sample size.[5, 6] This makes the search for financial resources even more complicated than in other medical fields.[2] Furthermore, it is hard to standardize the treatment, because it has to adapt to a variability of motor impairments and it is influenced by the therapist's characteristics, which in turn influence the patient's answer to the treatment.[7]

As well as for other biomedical sciences, scientific literature on neurological physiotherapy is highly characterized by studies conducted on homogeneous diagnostic areas.[8] This choice derives from the attempt to reduce the "selection bias", which consists of errors connected with the sample characteristics and subjects' allocation into groups.[9-11] As a consequence, the ap-

Table I.—*Bibliographic research strategy on Medline database.*

1 Akathisia, drug-induced	39 Hepatolenticular degeneration	77 Pituitary apoplexy
2 Alcohol-induced disor., nervous system	40 Hereditary CNS demyelinating diseases	78 exp Poliomyelitis
3 Amyotrophic lateral sclerosis	41 exp Heredodegener. disor., nervous system	79 Shy-Drager syndrome
4 exp Basal ganglia cerebrov. disease	42 Hippel-Lindau disease	80 Spastic Paraplegia, Hereditary
5 Botulism	43 Hydrocephalus	81 exp Spinal cord diseases
6 exp Brain damage, chronic	44 Hypothalamic diseases	82 exp Spinal cord injuries
7 exp Brain diseases	45 exp Hypoxia-ischemia, brain	83 exp Spinal cord neoplasms
8 exp Brain infarction	46 exp Intracranial arterial diseases	84 exp Spinal cord vascular diseases
9 exp Brain injuries	47 Intracranial arteriovenous malformations	85 exp Spinocerebellar degenerations
10 exp Brain ischemia	48 exp Intracranial embolism and thrombosis	86 Sturge-Weber syndrome
11 Brain neoplasms	49 Intracranial hemorrhage, hypertensive	87 Subarachnoid hemorrhage
12 Bulbar palsy, progressive	50 exp Intracranial hemorrhage, traumatic	88 Subdural effusion
13 Canavan disease	51 Intracranial hemorrhages	89 Tauopathies
14 exp Central nervous system cysts	52 Intracranial hypertension	90 Thalamic diseases
15 Central nervous system diseases	53 Intracranial hypotension	91 or/1-90
16 exp Central nervous system infections	54 Isaacs syndrome	92 Activities of daily living
17 Central nervous system neoplasms	55 Kluver-Bucy syndrome	93 Biofeedback, psychology
18 exp CNS vascular malformations	56 Leukoencephalopathy, progr. multifocal	94 Breathing exercises
19 exp Cerebellar diseases	57 exp Meningeal neoplasms	95 Drainage, postural
20 exp Cerebral arterial diseases	58 Meningitis	96 Early ambulation
21 exp Cerebral hemorrhage	59 Motor neuron disease	97 Exercise
22 exp Cerebrovascular accident	60 exp Movement disorders	98 Exercise movement techniques
23 exp Cerebrovascular disorders	61 MPTP poisoning	99 exp Exercise therapy
24 Craniocerebral trauma	62 exp Multiple sclerosis	100 Hydrotherapy
25 Dandy-Walker syndrome	63 Multiple system atrophy	101 Occupational therapy
26 Dementia	64 Muscular atrophy, spinal	102 exp Orthopedic equipment
27 exp Demyel. autoimmune dis., CNS	65 Myelinolysis, central pontine	103 exp Physical therapy modalities
28 Diffuse cerebral sclerosis of Schidler	66 exp Myelitis	104 Rehabilitation
29 Dyskinesia, drug-induced	67 Nervous system diseases	105 Relaxation
30 Dystonia musculorum deformans	68 exp Neural tube defects	106 Relaxation techniques
31 exp Encephalitis	69 Neuroaxonal dystrophies	107 exp Self-help devices
32 Encephalomalacia	70 Neuroleptic malignant Syndrome	108 Splints
33 Encephalomyelitis	71 Neuromuscular diseases	109 Transcutaneous electric nerve stim.
34 Epilepsy	72 Neurotoxicity syndromes	110 Vibration
35 Gerstmann-Straussler-Scheinker dis.	73 Ocular motility disorders	111 Walking
36 Hallervorden-Spatz syndrome	74 Olivopontocerebellar atrophies	112 or/92-111
37 Headache disorders	75 Paraneoplastic syndromes	113 91 and 112
38 Heavy metal poisoning , nervous system	76 exp Parkinsonian disorders	114 113 and [adult]/lim

plication of the studies' results in the clinical practice becomes even more difficult. Indeed, the main aim of rehabilitation interventions is not working on the source of the pathogenic noxa but on the effects of the disease on the motor function.[7, 12]

The abovementioned problems may interfere when moving from EBM to EBP, which considers the best therapeutic choice based on the available scientific evidence.[4, 6]

The question which led us to this study is whether literature data may be used independ-

Table II.—*Bibliographic research strategy on Embase database.*

1 Axonal injury	18 exp Meninx disorder	35 exp General medical aids
2 exp Brain disease	19 Minamata disease	36 Hydrotherapy
3 exp Brain infection	20 exp Motor neuron disease	37 exp Kinesiotherapy
4 exp Brain injury	21 exp Myelitis	38 Low level laser therapy performance
5 exp Brain malformation	22 exp Nervous system inflammation	39 Muscle relaxation
6 exp Brain tumor	23 Nervous system injury	40 Muscle stretching
7 exp Central nervous system disease	24 Neurologic disease	41 exp Orthopedic equipment
8 exp Central nervous system infection	25 exp Spinal cord disease	42 exp Physical activity capacity
9 exp Central nervous system malformation	26 exp Spinal cord infection	43 exp Physical medicine
10 exp Central nervous system tumor	27 exp Spinal cord injury	44 exp Rehabilitation
11 exp Cerebellum disease	28 exp Spinal cord malformation	45 Robotics
12 exp Cerebrovascular disease	29 exp Spinal cord tumor	46 Transcutaneous nerve stimulation
13 exp Demyelinating disease	30 exp Spinal cord vascular disease	47 exp Vibration
14 exp Encephalitis	31 OR/1-30	48 exp Walking
15 exp Extrapyramidal syndrome	32 Bed rest	49 OR/32-48
16 exp Head injury	33 exp Exercise	50 31 AND 49
17 exp Meningitis	34 exp Feedback system	51 50 AND ([adult]/lim OR [aged]/lim)

ently from the pathology for which they were originally reported.

In order to answer this question, we carried out an analysis of the scientific literature on neurological physiotherapy aimed at: 1) showing the development and trends of neurological physiotherapy over the years; 2) verifying whether similar treatments are used for same outcomes in subjects with different pathologies.

Materials and methods

Research strategy

MEDLINE and EMBASE databases were consulted from their earliest date to December 2007, combining the MeSH terms of central nervous system (CNS) diseases with MeSH terms of physiotherapy treatments, such as physical exercises, application of physical therapies, aids and orthosis, occupational therapy. These MeSH terms were selected for each database by two expert physical therapists. The research was limited to studies including adult participants using the MeSH term *adult.* Ninety MeSH terms related to CNS pathologies and 20 terms concerning physiotherapy were found in Medline (Table I) while 30 and 17, respectively, were found in EMBASE (Table II). Once the research was completed, two authors (MS, SV) carried out an independent selection of the articles with respect to the following inclusion and exclusion criteria: studies on the efficacy of physiotherapy on adult subjects (over 18 years of age) affected by CNS damage were included, efficacy studies of therapies not strictly belonging to the professional-technical knowledge of the physical therapist (for instance: transcranial magnetic stimulation or acupuncture) and efficacy studies of neuropsychological rehabilitation were excluded. The selection was made by reading the title and the abstract. A third author (EG) was consulted in case of disagreement.

Cataloguing

All the selected articles were listed into an Excel spreadsheet with respect to: a) the article's progressive number; b) title; c) authors; d) journal; e) year of publication; f) publication type; g) pathology of participants included in the study.

We assembled the articles according to the following categories of study design: case report, uncontrolled (clinical trial without a control group); controlled (clinical trial with a control

Table III—*List of 20 outcomes and 37 treatments selected for the classification of the studies.*

Outcomes	Treatments	
1 Upper limb	1 Cardiovasc. training	21 Muscle strengthening
2 Lower limb	2 Pneumatic compression	22 Robotics
3 Trunk	3 Cycle	23 Sport therapy
4 Gait	4 ES antalgic	24 Magnetic stimulation
5 Balance	5 ES excitatory	25 Attentive input
6 Independence	6 ES sensorial	26 External sensorial input
7 Mobility	7 Ballistic exercises	27 Stretching
8 Pelvic floor	8 Bilateral exercises	28 Task oriented
9 wheelchair	9 Exercises with drugs	29 Neurophysiological approach
10 ROM	10 Feedback	30 Occupational therapy
11 Spasticity	11 FKT aspecific	31 Gait training
12 Sensitivity	12 Forced use	32 Wheelchair training
13 Strength	13 Hydrotherapy	33 Balance training
14 Oedema	14 Mental training	34 Relaxing training
15 Pain	15 Passive joint mob.	35 Sensibility training
16 Tremor	16 Motor relearning	36 Ultrasound
17 Fatigue	17 Repetitive movement	37 Vibration
18 Biologic P	18 Posture	
19 Muscle activ P	19 Problem oriented w.m.	
20 Cardioresp P	20 Cooling	

Biologic P.: biological parameters; Muscle activ. P.: muscle activity parameters; Cardioresp. P.: cardiorespiratory parameters; Cardiovasc. training: cardiovascular training; Pneumatic compr.: pneumatic compression; ES: electrical stimulation; FKT: physiotherapy; Passive joint mob.: Passive joint mobilization; Problem oriented W. T.: Problem oriented willed movement;

group: randomised/non randomized, crossover/parallel groups design) and review (systematic reviews, surveys, metanalysis). The articles that did not fall into these four categories were called other (for example, editor's letters, editorials or comments), while the articles without a clear title and abstract were called n.d. (not definable).

For the cataloguing according to the pathology we looked at the disease/s of the subjects enrolled in the study. These diseases were then organized into the following pathology groups:

— brain pathologies (*e.g.*: stroke, traumatic brain injuries, brain cancers, hydrocephalia, coma);

— combined syndromes (*e.g.*: motoneuron syndromes, demyelinating diseases);

— myelopathies (*e.g.*: myelolesions, compressive myelopathies, syringomyelia, poliomiyelitis);

— movement disorders (*e.g.*:Parkinson's disease, Huntington's disease, dystonia, tremor);

— cerebellar pathologies (*e.g.*: Friedreich's ataxia, cerebellar stroke).

Trials which enrolled subjects suffering from different pathologies were called *mix* (miscellaneous) and those with no specified pathology were called *n.d.* (not definable).

Classification

Once the cataloguing was completed, we proceeded with the analysis in order to verify how many times and in how many articles a treatment was used for the same objective in subjects suffering from different pathologies. For this purpose we selected out of the catalogued studies only the controlled clinical trials which included patients affected by the four most frequently studied neurological diseases: stroke, spinal cord injury (SCI), multiple sclerosis (MS) and Parkinson's disease (PD). Each article was classified according to the disease, the treatment and the outcomes considered. Because of the high number of outcomes and rehabilitation treatments considered in the articles (about

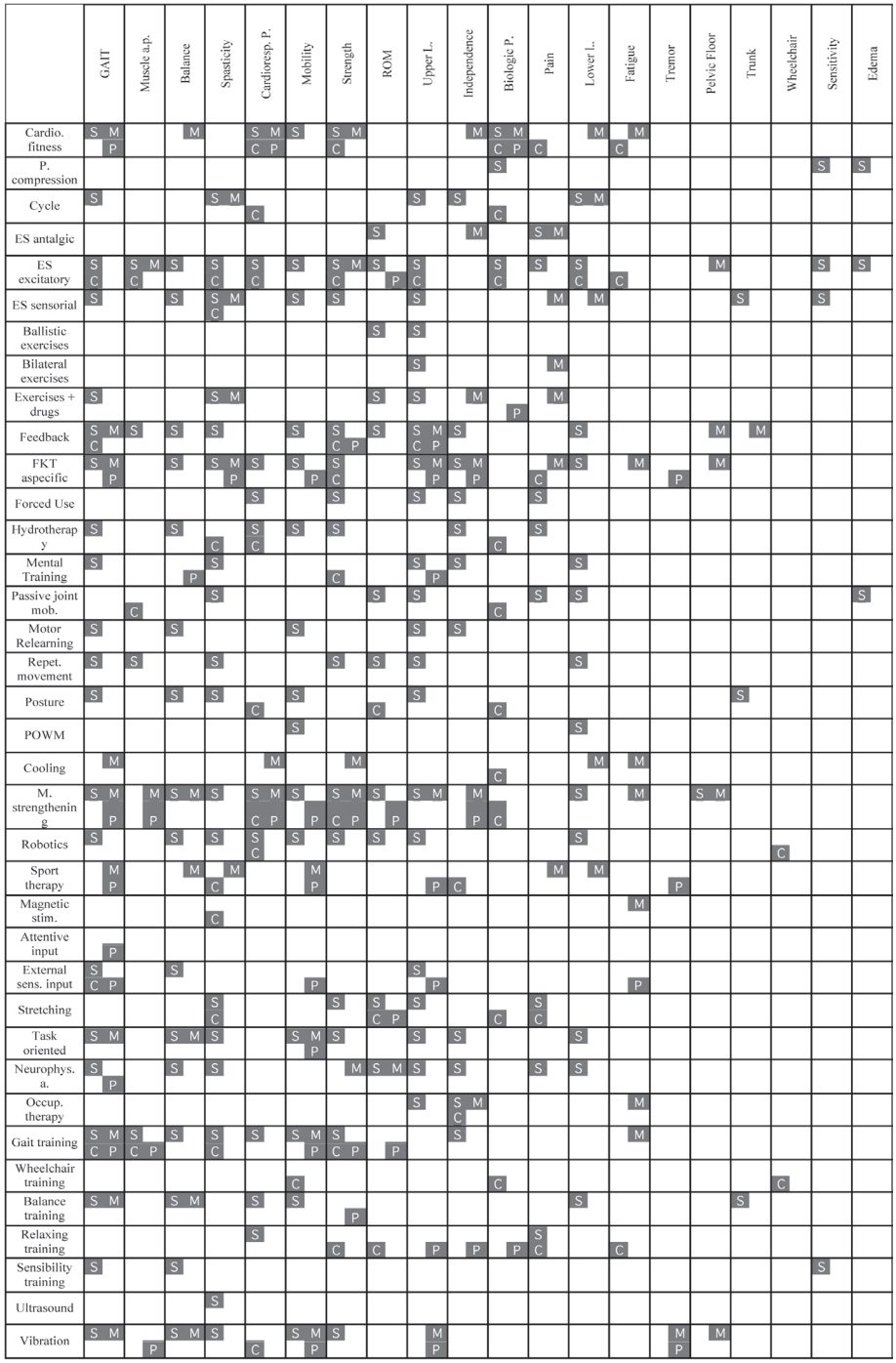

Figure 1.—The table shows which pathologies are studied for each association between outcome (column) and intervention (line). The pathologies are indicated by grey boxes within the cells (from 0 to 4 for each cell), containing the initial letter of the studied pathology. S: stroke; M: multiple sclerosis; C: spinal cord injury; P: Parkinson's disease. Muscle a.p.: muscle activity parameters; Cardioresp. P.: cardiorespiratory parameters; ROM: range of motion; Upper l.: upper limb; Biologic. P.: biological parameter; Lower l.: lower limb; Cardio. fitness: cardiovascular fitness; P. compression: pneumatic compression; Exercise + drugs: exercises with drugs; Repet. movement: repetetive movement; POWT: problem oriented willed movement; M. strengthening: muscle strengthening; External sens. input: external sensorial input; Neurophys. a.: neurophysiological approach; Occup. therapy: occupational therapy.

220 and 350, respectively), they were grouped in categories according to similar content. So, 20 outcomes and 37 treatments categories were identified (Table III).

By reading the abstract two of the authors (SV, MS) selected the studies and assigned them to categories of outcome and rehabilitation treatment. In case of disagreement a third author was consulted (EG). Once the classification was completed (Figure 1), it was counted, for each treatment, how many objectives it was studied for in subjects suffering from different pathologies, in subjects suffering from the same pathology, and finally how many objectives it was never used for. Moreover we calculated the corresponding number of articles.

Results

Cataloguing

From the bibliographic research more than 21 500 studies were found. Considering the inclusion and exclusion criteria 3065 studies were selected for the cataloguing. The number of journals in which these articles were published was 589.

Among the 3 065 studies, 1 144 (38%) were uncontrolled trials, 944 (31%) trials with a control group, 259 (8%) case reports, 184 (6%) reviews, 123 (4%) other, and 411 (13%) n.d.

In 96.8% of the cases (2 969 articles) the studies considered subjects affected by the same pathology: brain pathologies (1 709 studies, 55.7%), myelopathies (783, 25.5%), movement disorders (260, 8.4%), combined syndromes (202, 6.6%), cerebellar pathologies (15, 0.4%).

In 2.3% of the cases (72 articles) subjects with different pathologies (mix group) were included and 24 studies (0.8 %) were n.d..

The most studied pathologies were stroke with 1 304 articles (42.5%), SCI with 644 articles (21%), PD with 230 (7.5%) and MS with 175 (5,7%).

Literature trend and development

Over the considered period, there has been a progressive increase of both the number of studies concerning the efficacy of neurological physiotherapy and the number of journals where these studies have been published.

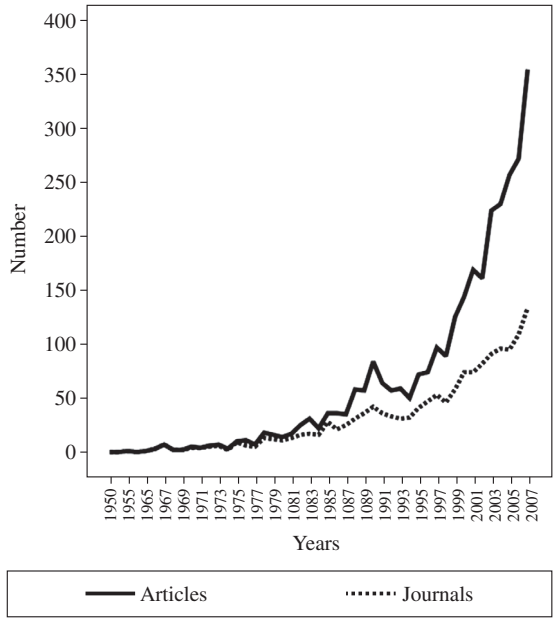

Figure 2.—The graph shows the trend through years of number of articles concerning the efficacy of the rehabilitation intervention in subjects with SNC lesions (dotted line), and the number of related journals (black line).

The average and the range of the number of studies and of their related journals were, respectively: 4.4 (0-19) and 3.6 (0-14) from 1950 to 1980; 41.1 (18-85) and 25.5 (14-43) from 1981 to1990; 84.1 (51-145) and 46.1 (32-75) from 1991 to 2000; 239 (162-356) and 98.2 (75-135) from 2001 to 2007 (Figure 2).

A different trend was observed for the various publication types: case reports and reviews remained less than 20 studies per year until 2006, reaching respectively 25 and 61 studies in 2007. The highest number of publications were reached by controlled and uncontrolled trials which showed a similar trend: a slight increase until the early 90s (less than 20 studies per year), a moderate increase between 1993 and 1998 (from 20 to 35 studies per year respectively), and a sharp increase from 1999 till 2007 (from 45 to 110 studies per year respectively).

The increase in the number of studies concerned all pathology groups, but especially re-

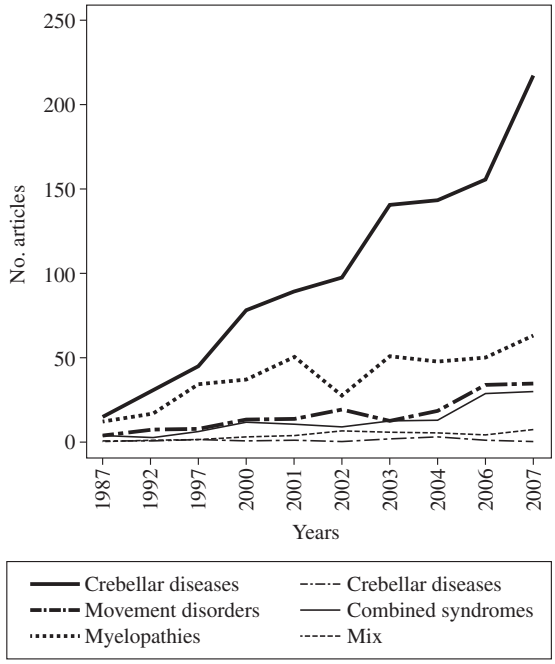

Figure 3.—The graph shows the trend through the years of the number of studies for each group of pathology: brain pathologies (black thick line), myelopathies (dotted thick line), movement disorders (dotted-point thick line), combined syndromes (black thin line), cerebellar pathologies (dotted-point thin line), mix (dotted thin line).

garded cerebral pathologies, which show a sharply increased from the late 90s: from 50 to 100 studies in the period 1999-2002 rising from 100 to 227 in the 2003-2007 period (Figure 3).

Classification

Among the 3 065 catalogued studies, 560 controlled trials were conducted on subjects with stroke (322, 58%), SCI (114, 20%), PD (69, 12%) and MS (55, 10%). The mean number of outcomes considered in each study was approximately 1.65 (range 1-6) and the mean number of treatments was 1.04 (range1-3). We remember, indeed, that each article could consider one or more treatment and outcome.

Figure 1 shows whether a treatment was studied for the same outcome for more than one disease. The figure shows the possible associations among the 20 outcomes and the 37 treatments, and points out how many pathologies, among the four considered, were studied for each association.

A first observation can be made by looking at the outcomes: only 3 out of 20 were studied on a single pathology. In particular, the wheelchair outcome was studied in SCI , while the edema and sensibility outcomes was studied in stroke. The remaining 17 outcomes are common for several pathologies: 11 outcomes for 4 pathologies, 3 outcomes for 3 pathologies and 3 outcomes for 2 pathologies.

The observation of the 740 (37x20) possible associations among interventions and outcomes leads to an interesting remark: 174 of them are studied on a single pathology and 69 on more pathologies (43 times on 2 pathologies, 20 times on 3 pathologies, 6 times on 4 pathologies). The 174 detected associations on a single pathology are studied in a total of 333 articles, whereas the 69 associations applied on more than one pathology are studied in 549 articles (that is the largest part of the considered studies:62.2%).

Discussion

The analysis of efficacy studies in neurological physiotherapy shows a gradual increase through years both in the number of published studies and in the number of journals in which they are published. This increase reveals that rehabilitation is a growing science, as well as other biomedical disciplines.

The analysis of the experimental designs reveals a similarity between the number of controlled and uncontrolled trials and this ratio does not change through years: the increase in the total number of publications does not match an increase in the percentage of controlled trials, although these are more helpful to evaluate the efficacy of the therapeutic intervention. This finding could depend on the aforementioned difficulties to conduct a RCT in the rehabilitation area, as the difficulty to find financial resources, to enrol large samples or to define standard interventions.[2, 5-7]

Another information which emerges from the cataloguing is that the research is concentrated on few pathological conditions: indeed, out of the 3 065 selected articles, 1 304 considered stroke, 644 SCI, 230 PD, 175 SM. This might depend on the relevance of these diseases for the health-

care system due to both their high incidence and the presence of a potential for functional recovery . Stroke, the most studied disease in neurological physiotherapy literature, records an annual incidence rate of 1.5 per 1000, increasing progressively with age.[13] Among the myelopathies, myelolesions are the most studied , with an incidence range from 11.5 to 57.8 cases per a million people [14, 15] according to the country. PD is a progressive and disabling degenerative disorder. The rise in incidence and prevalence of the PD (related to growing elderly population and reduction in other causes of mortality) and the limited efficacy of medical therapy, may explain the growing interest of neurological physiotherapy toward this pathology. Both incidence and prevalence of PD increase with advancing age and go from 4.9 to 23.8 per 100 000 (incidence) and from 31 to 138 per 100 000 (prevalence).[17] The combined syndromes most studied is MS, that is the most common demyelinating pathology. Its prevalence, related to the latitude, is relatively high in Northern Europe, North America and Southern Australia (30-80 cases per 100 000), moderate in Southern Europe and in the USA (5-30 cases per 100 000), and low in Asia and Africa (less than 5 cases per 100 000).[13]

As in all other biomedical disciplines, almost all the studies (97.7%) included participants affected by the same pathology. This procedure might have been selected for methodological reasons since considering a homogeneous group of subjects can reduce the selection bias.[9] Furthermore, this might be due to organisational reasons, as the healthcare services are usually branched into pathological areas. Finally, there might be a cultural reason: the target of medical and pharmaceutical interventions is the pathology itself; as a consequence, in these fields clinical trials on single pathologies are usually conducted. We suggest that this model has been embraced by physical therapy researchers without considering that rehabilitation focus on the motor impairment, that might be the same although caused by different pathological conditions.

The second part of this work presents the results of an analysis of the literature aimed at verifying whether the same rehabilitative treatments are used to obtain the same objectives in different pathologies.

From the analysis of the rehabilitation interventions it can be observed that they can be placed in the following categories: 1) exercises aimed at improving motor functions (*e.g.*: balance training, wheelchair training, muscle strengthening); 2) use of exercise instruments like robotics or cycle, 3) neurophysiological based exercises (*e.g.*: facilitation techniques). A definition of neurological physiotherapy, as it emerges from the literature, might be the following: a discipline which aims at improving motor functions, when necessary using a variety of tools, following a physiological rationale.

The fact that most of the outcomes (17 out of 20) are studied on more pathologies, shows that different pathologies could cause the same motor disorder. The outcomes measured in only one disease were: wheelchair (studied in SCI), edema and sensibility (studied in stroke). Undoubtedly the first is especially relevant for subjects with SCI, whereas the other two may be important also in patients affected by other pathologies than stroke, such as MS or SCI. The finding that this outcome is measured only in the literature on stroke rehabilitation is likely due to the higher number of studies on stroke than on other pathologies.

Almost all the researches present in the medical literature were conducted on samples of subjects affected by the same disease, but the results of our classification reveal that 69 times the same treatment was applied for the same objective in studies including participants with different pathologies. This suggests that rehabilitation interventions often concentrate on the motor impairment and not on the specific features of the pathology. This finding becomes even more important if we do not consider the association between the outcome and the intervention but the total number of studies. Indeed, the studies dealing with the same intervention for the same outcome in different pathologies are more frequent than those with treatment applied to only one disease.

Finally, it is interesting to observe that this

tendency does not concern only a few outcomes, but almost all of them.

The main limits of the present study are related to the need to assemble the great number of assessment tools (about 220) and treatments (about 350) used in groups of outcomes and treatments.

This implies that objectives or treatments also quite different could be included in a single category. Furthermore, because of the originality of this study, no pre-existing classifications were available. The categories were reviewed several times by the authors during the research and four expert physiotherapists found an agreement based on their personal experience.

Conclusions

The results of this study show a trend in neurological physiotherapy literature: treatment is focussed on motor deficit even when trials enrol participants suffering from a specific disease. This fact could lead to a new way to approach scientific literature in neurological rehabilitation, suggesting the need to correlate the findings to the motor impairment rather than to the disease which caused it.

This consciousness could help clinicians to translate EBM into EBP, improving the number of available rehabilitative treatments.

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Physiotherapists and research

S. BOCCARDI

Dear Editor,

In the 1950s at least 10 my articles, written in collaboration with students of the newborn Physiotherapy school of Milan, were published on scientific journals. This proves how much I have always believed in the need for physiotherapists to be involved in the research. Many of the Rehabilitation Medicine pioneers were physiotherapists: Guthrie Smith, Brunnstromm (an excellent kinesiologist), Berta Bobath, Knott and Voss (Kabat method), Jaroslava Jarka (Vojta method), Feldenkreis (he also was a physicist), Mille Mézières, Mc Kenzie.

Later on, I have always tried to involve physiotherapists in the research. This became easier as research became necessary for centers engaged in physiopathology of motor function, as for example the Don Gnocchi Bioengineering Center of Milan or the Polytechnic of Milan. I like to underline that data acquisition in these laboratories has always been handled by physiotherapists, that I thank for their precious help. Among the elected members of the SIAMOC (Italian Society of the Clinical Movement Analysis), Scientific Society of which I am honorary chairman, there have always been physiotherapists. I hope that one of these physiotherapists will soon become President of the Society.

For these reasons I appreciated and accepted the invitation to write on the first issue of the Italian Journal of Physiotherapy.

I have always believed that even in Rehabilitation Medicine the terms are decisive and a consensus on their significance is necessary for the affirmation of this discipline. In this field two words need to be specified: "science" and "research". I attended elementary and middle school in an atmosphere of rivalry between the two cultures identified by Baron Snow, and I preferred humanities over science. For a physician of the 1950's it seemed more relevant to understand the many terms of Greek origin rather than to know the Newton's laws. For example, I was told that "the sciences" do not exist, there is only one science: the physics. Therefore, it was not difficult for me to believe that a rehabilitation science does not exist. Rehabilitation Medicine is a discipline based on other scientific disciplines, such as functional anatomy, physiology, biomechanics, neuropathology, the study of behavior and so on. I learned that, in this discipline, scientific means precise, accurate, systematic and methodical. In other words, honest.

With regards to the term "research", I remind the Luigi Tesio's presentation held in Pavia in 2007 during a meeting on the specificity of the research in Rehabilitation Medicine. He states that Rehabilitation Medicine differ from other medical disciplines. In fact, its purpose is primarily behavioral and some factors such as independence, fatigue, and risk of fall cannot be extrapolated from the conventional physiochemical measures. Rehabilitation Medicine concern with the phenomenon and not with the cause, with taking care rather than healing. It seems closer to other specialties such as Preventive Medicine or disciplines related to the patients' age such as Pediatrics and Geriatrics. The outcome, the result perceived by the patient, is evaluated by item-response questionnaires rather than by numeric data.

Moreover, counting is not measuring, and measuring does not implicate a decision. For a patient there are only two possibilities: either an event occurs or it does not, and we can measure this probability. The question is whether the event we are studying, for example recovery, is due to chance. Many variables, related to the person, can influence the results of a treatment. These variables include autonomy, pain, balance, quality of live, manual skills, fatigue and mental retardation. Moreover, the interactions between the therapist and the patient are decisive in a teaching-learning paradigm. For an old post-stroke patient it can be determinant to meet a young well trained physiotherapist, even better if a young nice lady. The wise Milani Comparetti warned us: "do not give the child a therapy, give him a physiotherapist".

The intervention program, must be tailored on the patients' necessities and must be multi-component. For every single patient there is a different cocktail of interventions that has to be prepared using reliable interventions. Further, it has to be centered on the *bee* with the aim to adjust the estimates of the means to the person (who is the object of our interest): the *beehive.* I like to think that the beehive represents the patient's physical and social environment,

which must be taken in great consideration when a rehabilitation program is planned.

About the statistical analysis, it is important to remember that specific variables, specific measuring methods and specific statistical techniques are requested. Therefore, specific experimental designs should also exist. Much of the published work concludes with expressions like: "In such patients it is likely that...", "We seem to be able to conclude ..", "The heterogeneity of the results ...", "The small number of cases does not allow us to conclude ...", "Further investigation is necessary ...". Rarely these further investigations are then carried out.

Thirty years ago Cochrane told me (I was the President of the International Rehabilitation Medicine Association) about the difficulty of demonstrating the effectiveness of most rehabilitation techniques. On the other hand, it has often been said that "'until these therapies are sound-based, skepticism and criticism are inevitable" and every day we have to face others' skepticism and criticism and our own doubts.

What is the best approach to strengthen the muscles of a subject after a stroke? In this case is a measure of strength appropriate? Is it effective to restrain the healthy upper limb? Is it possible to increase the length of contracted hamstrings by stretching? Is there a difference in the cardiovascular responses during isotonic and isokinetic exercises? I fear that for many of these (and many others) questions there still are not the final answers.

Moreover, how should exercise dosage be evaluated? This is a fundamental aspect in the research on the effectiveness of a therapy. It is possible to measure the duration of a standard session, for example one hour four times a week, but it is less easy to measure the intensity and the duration of an individual muscle contraction or the interference of training and fatigue on the motor results. And so on for dozens of other parameters.

Taken these difficulties into account, we must not "give up" the research.

The physiotherapists' contribution is fundamental in order to: verify the validity of the theories underlying the rehabilitation techniques, select and apply the techniques on a large and homogeneous sample and to guarantee a correct management of the treatments.

In the time that is left to me, I would like to avoid reading statements like 'the sample is not sufficient' or 'further research is needed". In this case it is better not to publish, unless the singularity of the cases justifies the publication.

Multicenter studies which involve the collaboration of different teams have to be facilitated. In a recent and accurate meta-analysis (Corbetta D. Eur J Rehab Med, 2011) about the effectiveness of the constraint induced movement therapy for upper limb recovery after stroke, the authors underline the need of methodologically well-done studies, with adequate sample sizes. In particular, the authors consider that the results of a large multicenter study is more reliable than those of a meta-analysis conducted on many small studies.

The physiotherapist can also be involved in the choice of the evaluation criteria, for example in selecting the most appropriate and reliable measure. Also on the feasibility and interest in the use of new instrumental techniques the physiotherapist can offer expertise. For example, as already mentioned, in the evaluation of motion analysis techniques.

The physiotherapist is the practitioner that better is able to appreciate, not only the patient's tolerance/compliance to the treatment, but also the treatment's ecological effect. I mean what the patient is really able to do during his everyday life.

I have often recalled the Popper concept: "also a small but reliable contribution can be useful for the advancement of knowledge".

So, get busy.

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