Stance is characterised by the exchange of contact forces between the body contact surface and the ground. These forces normally act in the same direction as gravity, i.e., the vertical direction. When acceleration subjects the body to forces that act in other directions, contact forces lose their vertical action. Therefore, the body is organised to withstand not only gravity but also contact forces. Under static conditions, projection of the centre of mass (COM) of the body must be within the base of support formed in humans by the outer borders of feet and by two imaginary lines linking the big toes and the heels. Under dynamic conditions, including velocity maximal limits of standing balance define a region of dynamic stability.

Two main models have been proposed for studying and interpreting body movements during stance. The inverted pendulum model is particularly useful when dealing with body sway during quiet stance. Under this condition, the human body is considered an inverted pendulum, its pivot corresponding to the ankle joint and its mass concentrated at the level of pelvis. The two-link model describes movements of the body around ankle and hip joints, triggered by a postural perturbation, assuming the knee as a rigid link. Quiet upright stance is maintained with minimum energy expenditure. During quiet stance, body sway oscillations are small, and mainly in the anterior-posterior direction. Under this condition, balance is mainly maintained through stiffness of muscles, ligaments and joints. Minimal ankle stiffness is required to stand, and reflexes driven by muscle afferents significantly contribute to balance-related ankle stiffness regulation. Quiet stance requires low level tonic EMG activity in the anti-gravity soleus muscle, whilst all the other muscles but the biceps femoris and spinae erectors remain almost quiescent.

The stabilisation of upright human stance after external disturbances depends on the integrative evaluation of afferent information from visual, foot sole skin, vestibular and proprioceptive inputs. The availability of this sensory information may be critical to restore balance following external disturbances. Nevertheless, the redundancy of sensory input involved in the control of balance allows balance to be preserved even when one or two afferent inputs are lost. Postural stability generally decreases in the absence of visual input, or in experimental conditions that alter the quality or type of visual input available. Movements between the support surface and the feet generate shearing forces that can result in stretching and deformation of the skin and lead to activation of cutaneous and deep mechanoreceptors. Vestibular control of posture may be important at low body sway frequency such as during quiet stance, or slow perturbations of stance, but not during fast perturbations. The vestibulo-spinal system gain is normally very low in quiet stance on a firm surface. No relationship between EMG activity of triceps surae muscle and changes in the ankle angle due to body sway are observed during quiet stance, suggesting that postural corrections do not depend strictly on reflexes mediated by group Ia spindle fibres. However, an important role for group II spindle fibres in balance control has recently been suggested from results obtained from various protocols.
Postural instability (PI) is one of the most disabling disorders associated with neurological diseases. PI often leads to falls, bone fractures and causes the so-called “fear of falling” (FOF), which further increases the tendency to immobility of patients with balance deficits. PI is frequently present in stroke, Parkinson’s disease (PD), multiple sclerosis, closed brain injury, cerebellar dysfunctions and in many diseases affecting the visual, somatic and vestibular sensory systems. In spite of the considerable clinical significance of this disorder, the literature dealing with rehabilitation of PI is very scant. Most of the studies in this field concern vestibular and stroke rehabilitation whereas only few group and single case studies are available in relation to PD and cerebellar diseases. Our experience in the rehabilitation of PI concerns mainly stroke and PD. The causes of PI in stroke could be related to dysfunctions of feedback and feed-forward mechanisms of postural control and also to deficits of integration of somatosensory inputs. Moreover, in some patients with stroke, PI often follows neglect or the “ipsilateral pushing” syndrome. We performed two preliminary studies in patients with stroke. The first was aimed at testing the effectiveness of a training schedule consisting of exercises stimulating postural reactions under visual deprivation and under other conditions of sensory conflict (compliant support surfaces, use of a head dome, etc.). Six patients were investigated, before and after the training, through application of the Sensory Organisation Test (SOT), static posturography, and walking speed parameters. Results showed that after training, in spite of globally constant posturographic data, all the patients displayed greater postural stability in the SOT and increased walking speed. These results have very recently been confirmed in a study by Bonan et al. (2004). The second stroke study was aimed at evaluating the effectiveness of a rehabilitation training for ipsilateral pushing. Ipsilateral pushing is a clinical disorder following left or right brain damage in which patients actively push away from the non-hemiparetic side, leading to a loss of postural balance. These patients perceive their body as “upright” when it is actually tilted to the side of the brain lesion (i.e., to the ipsilesional side). Patients with ipsilateral pushing take 3.6 weeks longer than patients without it to reach the same functional outcome. Nevertheless, rehabilitation studies of ipsilateral pushing are not available. We examined 7 stroke patients presenting with ipsilateral pushing at least 3 weeks after onset of the disease. We trained these patients according to the rehabilitative treatment suggested by Karnath et al. (2003). One week before treatment and immediately before and after treatment patients underwent a battery of tests: the Scale for Contraversive Pushing, the European Stroke Scale, the Modified Barthel Index, the Motor Assessment Scale and the Modified Burke Stroke Time Oriented Profile. Results showed that the baseline pre-treatment performance was stable and that after treatment patients significantly improved their postural stability and their ability to perform activities of daily living.

It is widely known that PI is one of the most disabling symptoms of PD, in which it is not amenable to pharmacological treatment. Current rehabilitation approaches in PD consist of exercises not specifically aimed at overcoming PI. In a previous randomised controlled trial of 24 PD patients, we examined the effectiveness of a new rehabilitative treatment aimed specifically at increasing the postural stability of patients with PD. Patients were divided into two groups. The first group was submitted to the novel rehabilitative training and the second to exercises aimed at increasing motor coordination and range of movement. Before and after treatment all patients underwent a test of self-destabilisation of centre of foot pressure (CFP), a test of transfer ability (from supine to sitting, and from sitting to standing position) and a static posturographic test under open and closed eyes conditions, respectively. The results showed that patients in the study group achieved a significant improvement of performance in the test of self-destabilisation of CFP, in the test of transfer ability and in the closed eyes condition of the posturographic test. A non significant improvement was obtained in the open eyes condition. Patients in the control group did not show any statistically significant variation in any outcome measure. The present data underline the importance of rehabilitation of PI in neurological diseases.
BIOFEEDBACK IN REHABILITATION: USEFULNESS AND RESULTS IN NON-CEREBROVASCULAR DISEASES

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In rehabilitation, biofeedback (BF), particularly electromyographic biofeedback (EMG-BF), plays an important role in the treatment of upper motor lesions, mostly sequelae of cerebrovascular events. BF is applied mainly in the retraining of motor skills and the inhibition of spasticity due to brain injuries of all types and at all ages. Therefore, EMG-BF may be useful in the rehabilitation of patients affected by other neurologic diseases, such as cerebral palsy, spinal cord injuries, multiple sclerosis, dystonias, and peripheral nerve denervation. Biofeedback is useful for teaching exercises, for motivation, and for compliance, and treatment is safe and low risk with no documented side effects. However, the actual effectiveness of BF in the rehabilitation of non-cerebrovascular diseases is still debated, because of major methodological problems. Therefore, large multicenter studies, using the same inclusion and exclusion criteria, BF protocol, and methodology are needed to clarify any doubts.

Biofeedback treatment is an effective adjunct to physical therapy in children with cerebral palsy. BF has been shown to be effective for ambulation, measured by gait function, tonus of plantar flexor muscles and active ROM of ankle joints and for reduction of spasticity of the triceps surae. Moreover, BF treatment improved gait symmetry and was associated with greater ankle power for push-off, as well as increases in total positive work at the hip and ankle.

In spinal cord injuries, EMG-BF training has been shown to be effective in reducing Trendelemburg gait in patients with incomplete lesions and in increasing voluntary EMG responses in long-term spinal cord injury patients. In multiple sclerosis, BF retraining has been found to be an effective treatment in some patients complaining of constipation or fecal incontinence, but unsatisfactory in patients with bladder dysfunctions. Moreover, EMG-BF improved the clinical and electromyographic outcome in 9 out of 10 patients with writer’s cramp; EMG-BF was also effective for preventing the development of synkinesias after facial palsy, in reducing torticollis, and in improving chronic tic disorders.

USE OF EMG TRIGGERED STIMULATION IN STROKE REHABILITATION

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Recently introduced into clinical practice, electromyography-triggered neuromuscular stimulation (EMG-FES) combines the benefits of electrostimulation with those of biofeedback training. It also allows the increased effect of residual muscle contraction to be observed, which is rewarding for patients; this aspect is of fundamental importance and underpins the theory of sensorimotor integration, wherein impulse sensations deriving from movement of the paretic limb influence motor output: indeed, many studies have shown a close correlation between motor recovery and motor learning. The first studies using this type of functional electrical stimulation (FES) were conducted by Vodovnik; he reported that active exercise combined with FES produced better performance. The first system able to produce FES and voluntary muscle contraction was then designed: the patient’s voluntary activation of a muscle group works as a trigger for the electrical discharge.

Several years later, Bowman et al. developed a training programme which was applied to the lower and upper limbs. Following Vodovnik’s studies and a pilot Danish study, Fields, investigating patients affected by hemiplegia of at least 6 months’ duration, found a better performance in the EMG-FES group. In a group with hemiplegia lasting less than 6 weeks, Francisco et al. showed that upper limb performance had improved in the EMG-FES group. In patients affected by hemiplegia for at least 1 year, Cauraugh et al. demonstrated better performances in EMG-FES group, and in a more recent study obtained significant findings in group undergoing EMG-FES bilateral training. Despite the interesting scientific implications, the indications for this type of electrostimulation are limited. Eligible patients are highly cooperative and motivated and present with greater residual muscle activation, and it should be noted that all the studies were carried out on small groups of patients, which limits the significance of the results.

Nevertheless, in a very interesting study Popovic et al. treated the arm of subjects with acute hemiplegia with functional electrical therapy (FET), an exercise programme that comprises voluntary arm movements that are assisted by a neural prosthesis; they found larger gains in upper limb activity in the FET group. The next challenge could be to associate FET and EMG-FES protocols in the rehabilitation of upper limb in stroke patients to see whether the coupled protocols lead to motor recovery and gain of arm function.

FUNCTIONAL ELECTRIC STIMULATION IN HEMIPLEGIC PATIENTS

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To recover walking capacity is one of the main aims of functional recovery programmes in hemiplegic patients. Deficient control of foot dorsiflexion, the most frequent functional handicap deriving from stroke, is one of the main factors giving rise to a low efficiency gait pattern. Electric stimulation of the external popliteus sciatic nerve, activated during swing phase, induces a foot dorsiflexion which is independent of selective voluntary activation capacity. Therefore, this modality could be pro-
posed as a useful therapeutic support for rehabilitation programmes. There is evidence, in scientific literature, that the functional improvement induced by this therapeutic approach is greater than that obtained through conventional physiotherapy. In particular, a faster walking speed, reduced energy cost in gait, better ankle and knee control and improved footstep symmetry have been observed. On the other hand, on the basis of the scientific evidence, functional electric stimulation of the peroneus may be also be proposed in order:

- to maintain the contraction characteristics of the foot dorsiflexion from the post acute phase, since lack of use due to the plegic or paretic condition may induce structural, morphological and metabolic damage to the foot dorsiflexor muscles. In a long-term programme tibialis anterior training may be considered as the first step to reach an activation good enough to ensure dorsiflexion even in the event of surgery, in order to improve balance in inversion in the event of failure of functional voluntary activation of foot etversors in the oscillation phase;
- to increase the muscle-skin, tendon and articular proprioceptive sensitive stimuli;
- to reduce the retraction risk due to the absence of dorsiflexion on Achilles tendon;
- to induce plantarflexor muscle inhibition through the dorsal/plantar flexor reciprocal inhibition mechanism;
- to induce a lower limb flexor pattern reflex that allows a more efficient lower limb movement due to activation of hip and knee flexors in synergy with foot dorsiflexion.

**BOTULINUM TOXINS: MECHANISM OF ACTION AND NEW THERAPEUTIC INDICATIONS**

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The botulinum neurotoxins (BoNTs) are zinc-dependent proteases and seven different ones are known, denominated with the letters of the alphabet: serotype A (BoNT-A), B (BoNT-B), C (BoNT-C), D (BoNT-D), F (BoNT-F), G (BoNT-G). Since the 1980s, BoNTs have been used in clinical practice as a symptomatic therapy for the treatment of various pathological conditions characterized by “autonomic cholinergic hyperactivity”. The BoNTs are synthesized in the form of single polyprotein inactive chains of 150 KDa and they are formed from one “heavy chain” (chain H) of 100 KDa united with one “light chain” (chain L) of 50 KDa. In nature, the diffusion of the neurotoxin (complex H-L) occurs primarily via the circulation system, reaching the cholinergic peripheral nerve terminals where it stops the release of acetylcholine from the vesicles (quanta). At the cholinergic synapse, BoNT interacts with receptors situated on the presynaptic membrane, entering through a mechanism of endocytosis, and exerting its action through the N-terminal half of the “heavy chain H”. The receptor recognition mechanism has yet to be fully clarified, nevertheless 3 classes of receptors have been identified: one for BoNT-A, one for BoNT-E and one for BoNT-B, G and E. Once it penetrates the cytoplasm of the presynaptic terminal the “chain L” it exerts its action through a proteolytic mechanism on some proteins of the apparatus of neuroexocytosis, known as “snare-complex”, that are implicated in the release of acetylcholine from the synaptic vesicles. The different BoNTs exert their action through a zinc-dependent mechanism that stops the “snare-complex” system in a way that is irreversible, but nevertheless selective and specific for each serotype. In particular, the BoNTs B, D, F and G cut the protein “VAMP”, BoNT-A and E the protein “SNAP 25” and BoNT-C the proteins “syntaxin” and “SNAP-25”. The physiopathological consequence of the action of the BoNTs is thus the functional death of the cholinergic synapse, which leads to “muscular denervation”. The reactive mechanisms and consequences of this poisoning appear, to an extent, similar to those present during “complete muscular denervation” after a neurogenic lesion (axonotmesis). Indeed the phenomenon of “sprouting” is different from that of the nervous axonal lesions, because BoNTs do not induce a modification of the motor unit dimensions. In this report all the critical factors that modify and cause a different therapeutic effect will be illustrated (diffusion, concentration, doses, various BoNTs used, etc.), while the possible mechanisms of the BoNT in new and different pathologies characterized by “autonomic cholinergic hyperactivity” and/or by “pain” will be discussed. The BoNT-A mechanism providing pain relief is hypothesized to be something other than muscle relaxation by inhibiting the release of ACh at the neuromuscular junction, such as inhibition of the release of substance P or the blocking of autonomic pathways, etc.

**THE ROLE OF BOTULINUM TOXIN IN THE MODULATION OF PERIPHERAL AFFERENT NERVES: PERSPECTIVES IN REHABILITATION**

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The treatment of focal dystonias has received considerable impetus thanks to the introduction of type-A botulinum toxin (BT-A) therapy. BT-A binds to the presynaptic nerve endings at the level of the neuromuscular junction, inhibiting the release of acetylcholine and provoking transitory muscle paralysis due to chemical denervation. However, animal studies have shown that BT-A also acts at the level of the neuromuscular spindles, inducing their deervation as a result of the action of the toxin on gamma receptors on peripheral nerve fibres and thereby altering the flow of sensory information from the muscle to the central nervous system. In man, various neurophysiological approaches have de-
Cervical dystonia (CD), the most frequent idiopathic focal dystonia, often begins in the middle of productive life and causes serious functional disabilities. CD consists of involuntary sustained or intermittent muscle contractions causing twisting and repetitive movements, abnormal postures, or both. Clinical features can also be complicated by pain, tremor, “geste antagoniste” and secondary impairments due to compensatory postures.

Injections of botulinum toxin type A (BTX) have been shown to be safe and effective in the management of CD since the late 1980s, reducing the activity of muscles responsible for involuntary postures and movements. But BTX is not always effective on secondary impairment and consequent disability.

The aim of this randomized, controlled, cross-over study was to evaluate the efficacy of an integrated treatment for CD with BTX injections and a specific rehabilitation program (FKT). Forty patients with CD were randomized into 2 groups: Treatment Group 1 received BTX treatment followed by a 15 days’ FKT program, and Treatment Group 2 received BTX alone. Evaluation scales (TSUI and TWSTR scales for CD severity, ADL scale for functional disability, VAS scales for pain and subjective wellness related to illness and treatment) were performed before treatment and 15, 45, 90 and 120 days after it by a physician blinded to the patient’s study group. Any time after the 45th day, if TSUI and TWSTR scale did not show any improvement, the patient entered the other treatment group (cross-over phase). All the patients completed the study, undergoing both treatments (BTX alone and BTX + FKT). Treatment 1 produced a significant improvement in BTX efficacy duration in relation to Treatment 2, with lower BTX dosages, even though the difference was not statistically significant. Moreover, ADL and VAS pain scales showed a significantly greater improvement after Treatment 1 than Treatment 2. No significant adverse effects were reported after either treatment. This study demonstrates that a specific rehabilitative program associated with BTX therapy allows CD treatment to be developed in terms of a lengthening of the effect duration and improvement of functional disability and pain.

**BOTULINUM TOXIN: NEW PERSPECTIVES IN PAIN THERAPY**

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Botulinum toxin (BTX) has become the “treatment of choice” for certain centrally mediated movement disorders such as blepharospasm, dystonia, etc. In recent years, BTX has been reported to reduce muscle pain. Initially, the efficacy of BTX was related to its capacity to reduce muscle spasms/hyperactivity, and its efficacy in pain related to dystonia and spasticity was described. Recent data indicate that BTX is able to interact with several neurotransmitters (e.g., substance P) involved in pain transmission at central level. These data represent the basis for using BTX in several pain conditions with or without muscle hyperactivity. Recent evidence indicates that BTX may be useful in the treatment of tension type headache and migraine (episodic and chronic) with or without drug overuse. Moreover, the use of BTX has also been suggested to be effective in whiplash syndrome, cervicogenic headache, orofacial pain, myofascial pain syndrome, low-back pain and other pain conditions.

**BOTULINUM TOXIN TREATMENT IN SPASTICITY: A TRADE OFF BETWEEN EFFICACY AND EFFECTIVENESS**

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Spasticity is recognised as a major problem in the management of patients with upper motor neuron lesions who experience difficulties in self-care activities, in maintaining or changing body position, and in fitting orthoses, as well as contractures and, therefore, severe disabilities. In the last few years, the traditional approach to spasticity has changed as a result of the availability of new therapeutic options.
Choosing the most suitable therapeutic approach is a dynamic process which must take into account clinical conditions (i.e., residual motricity, degree of hypertonus, abnormal postures) and the patient’s expectations (in terms of pain relief, facilitation of nursing activities, functional gain). A multimodal approach is acknowledged as the best treatment, particularly when specifically "timed and fitted" to enhance its effectiveness. This effectiveness is strictly related to a reduction of muscular tone, while its contribution to functional gain is still debated. Only subgroups of patients with residual motricity can, through the reduction of co-contraction, derive functional benefit from botulinum toxin (BTX-A) treatment. Reduction of self-care difficulties could be possible using BTX-A injections in patients with severe upper limb or adductor spasticity. Furthermore, we should distinguish between interventions carried out exclusively upon onset of impairment (with the aim of underlining functional gain) from interventions performed after the appearance of stiffness, pain and discomfort (in order to prevent any further complications). Hypotheses now being advanced include the use of BTX-A as a prophylactic treatment of spasms and contractures in the early stages of stroke and traumatic brain injuries. Patients should be advised of the objectives and modes of treatment, and expected goals should be made quite clear to the patient in order to avoid disappointments and the jeopardising of future approaches. Spasticity management is mainly "physical" and BTX-A injections are oriented towards the optimisation of rehabilitative programmes. For example, the use of BTX-A in focal spasticity makes it possible to perform stretching therapy, which allows more effective prevention of muscular rheologic changes. The long-term use of BTX-A shows that its effectiveness is unchanged over time and that it allows longer intervals between injections, thus reducing the economic burden of the treatment.

Functional outcome in terms of ability to walk, self care and ability in activities of daily living are the most important issues for patients who have recently sustained a spinal cord injury. The prediction of the dysfunction is important both to the patients and their families, and to the treatment team, in order to plan the right comprehensive rehabilitation. In recent years our knowledge of neurological recovery has increased to the point at which we can easily predict the recovery in terms of muscular strength and sensory activity. A review of the literature has shown that administering a neurological examination during the period within 72 hours and the 1st week of trauma is useful for predicting neurological outcome. The motor manual test in the upper and lower extremities, the evaluation of the preservation of sensation with pin prick and light touch tests according to the ASIA impairment scale, were used. Moreover there is agreement on the fact that the age of the patient is a major influence on outcome as well as on early comprehensive rehabilitation. In addition to this clinical approach, some other authors maintain the importance of early use of technical devices, such as: myelography, CT-myelography, MR images, somatosensory evoked potential (SEP), and hyperbaric oxygen therapy.

From our clinical experience we can affirm that the clinical evaluation is the main and most useful factor in predicting neurological and functional outcome. The application of SEP tests and MR images will help to further refine prognosis. We also suggest that it is fundamental to consider factors influencing the neurological recovery such as age, associated injuries and clinical status before injury.

**OUTCOMES FOLLOWING TRAUMATIC SPINAL CORD INJURY**

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A fascinating aspect of spinal cord injury (SCI) rehabilitation is uncovering the direct relationship between the level and severity of the spinal cord lesion and the functional outcomes that a given patient could eventually achieve. Many investigators have published outcome studies that investigate actual outcomes by level of injury. However, the ideal outcome may not always be achieved. Personal choice (energy conservation, personal preferences, fear, anxiety, availability of attendant care, psychological factors) and coexistent conditions (age, obesity, pre-existing medical conditions, spasticity, contractures, concomitant injuries, upper extremity injury, depression, cognitive impairment, availability of financial resources, social and cultural factors) must be considered as variables liable to cause deviations from expected outcomes. The rehabilitation team evaluates the individual patient and defines expected outcomes before deciding the rehabilitation programme that must be followed in order to achieve those outcomes. Creativity in programme design is encouraged and the person with SCI is given the freedom to pace his or her progress according to his emotional and physical recovery. Expected outcomes of SCI and their measurement are divided into three domains:

a) motor recovery;

b) functional independence;

c) social integration.

a) 80% to 90% of patients with complete injuries (ASIA A) – evaluation based on neurological assessment within the first week of injury – will remain complete. Of those who switch to incomplete injury status, only 3% to 6% will recover functional strength in the lower
the Six-minute Walk Test (6MWT) was performed, du-
per treadmill session. At the end of training,
without BWS and walked a distance of at least 500 m
was stopped when the patient achieved 30 minutes
tion and percentage of BWS were recorded. Treatment
muscular strengthening. Heart rate (HR), speed, dura-
sion included training on the treadmill with body weight
pered for 3 hours/day, for a mean of 9.5 weeks. Each ses-
D12-L1) about one year after trauma. They were trea-
proves gait and endurance.
A series of essential daily functions and activities,
expected levels of functioning, and the equipment
and the attendant care likely to be needed to support
the predicted level of independence cover the fol-
lowing areas:
– respiratory, bowel and bladder function;
– bed mobility, bed/wheelchair transfers, wheelchair
propulsion and positioning/pressure relief;
– standing and ambulation;
– eating, grooming, dressing and bathing;
– communication (keyboard use, handwriting and te-
lephone use);
– transportation (driving, attendant-operated vehicle
and public transportation);
– equipment requirements;
– home modifications.
After achievement of functional goals, periodic eva-
uation of functional status is needed throughout the
individual’s life.
Rehabilitation should focus on providing opportuni-
ties for societal participation, in meaningful roles. Se-
veral measures of community integration and socie-
tal participation exist, like the Craig Handicap Assess-
ment and Reporting Technique (CHART).

CLINICAL EXPERIENCE OF WALKING TRAINING
IN SPINAL CORD INJURY

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In this study of patients affected by incomplete spinal
cord injury (SCI), stabilized at the end of post-acute
rehabilitation, we compared the energy cost (mLO2*Kg-
1*m-1) of wheelchair use with that of gait while wearing
an orthosis following intensive rehabilitation treatment;
a further aim was to assess whether this treatment im-
proves gait and endurance.
We recruited 5 patients with chronic SCI (lesion level
D12-L1) about one year after trauma. They were trea-
ted for 3 hours/day, for a mean of 9.5 weeks. Each ses-
session included training on the treadmill with body weight
support (BWS) and conventional physiotherapy with
muscular strengthening. Heart rate (HR), speed, dura-
tion and percentage of BWS were recorded. Treatment
was stopped when the patient achieved 30 minutes
without BWS and walked a distance of at least 500 m
(500-900) per treadmill session. At the end of training,
the Six-minute Walk Test (6MWT) was performed, du-
ring which the Vmax ST system by Sensormedics was
used to record energy cost and other respiratory para-
eters in patients wearing orthoses and in patients in
wheelchairs. We administered the Perry and Garrett
Walking Handicap Scale (Perry and Garrett), Functional
Ambulation Category (FAC), and Borg evaluation sca-
les at the beginning and end of training.
In our patients, energy cost and other parameters
(walking distance, speed, oxygen pulse, heart rate) recor-
ded during the 6MWT showed that walking while wearing
an orthosis is slower and more costly in energy terms
than using a wheelchair. Furthermore, wheelchair use
parameters were compared with normal walking parame-
ters and found to be very similar. All patients recorded
improved scores on the Perry and Garrett, FAC and Borg
scales; one interesting finding was the gait improvement
on the Perry and Garrett scale: all the patients recorded
1 on admission, while their mean score at discharge was
2.8; one patient achieved social autonomy with some dif-
giculty (Perry and Garrett=5). No patient worsened. Heart
rate values after exercise, despite the increased work on
the treadmill, remained relatively stable.
We observed that walking while wearing an orthosis is
more costly in energy terms than using a wheelchair,
but intensive treatment on patients with chronic SCI im-
proves endurance, and the possibility of functional gait.

PLASTICITY MECHAMISM UNDERLYING
WALKING RECOVERY IN SPINAL CORD INJURY
PATIENTS: A KINEMATIC STUDY

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Experience with spinal cord injured (SCI) patients indi-
cates that with training they can recover some locomo-
tor ability: in a recent study, 105 (70%) of 154 consecu-
tive patients with ASIA impairment C and D at admis-
sion showed some recovery of walking, a percentage
that rose to 100% depending on motor impairment at
admission and age. It is not clear whether locomotor re-
sponses depend on the re-activation of the normal mo-
tor patterns or on the learning of new ones. In recent
studies we have addressed this question by recording
detailed kinematic and electromyographic data in SCI
patients trained to take steps with body-weight-support
(BWS) and comparing them with healthy subjects. Pa-
ients with BWS could be trained to step in the labora-
ory conditions, but they used new coordinative strate-
gies. The BWS patients recovered the shape of the foot
motion, the foot trajectory reproducibility and the velo-
city-curvature relationship that characterizes normal
gait. On the contrary the phase relationship between
limb segments, the timing of segment angle kinematics
and the muscle activity patterns (as shown by the re-
constructed spatio-temporal maps of motor neuron acti-
vity) remained abnormal. Surprisingly, however, the
new motor strategies were quite effective in generating
close-to-normal foot motion in the laboratory conditions. Furthermore, in contrast to healthy subjects who can immediately reverse the direction of walking, SCI patients trained with BWS, when asked to step backward and on the spot, were unable to perform the tasks, but performed them after appropriate training. Therefore we suggest that locomotor responses in SCI patients may not be due to changes localized to limited regions of the spinal cord, but may depend on a plastic redistribution of activity across most of the rostro-caudal extension of the spinal cord. Distributed plasticity underlies recovery of foot kinematics by generating new patterns of muscle activity that are the motor equivalent of the normal ones. This hypothesis is reinforced by the fact that locomotor recovery does not transfer to untrained tasks. The locomotor programs encrypted in the reorganized networks allowed functional recovery of unsupported gait in most incomplete paraplegics, whereas they remained non-functional in most complete paraplegics outside the laboratory conditions, as these patients could not walk without body support.

INCOMPLETE SPINAL CORD LESIONS:
DATA AND REFLECTIONS ON RECOVERY
OF GAIT

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In relation to an initial clinical evaluation conducted using the ASIA scale, we therefore evaluated "photographically" the progressive neuromotor recovery of our patients, filming all the progress they made. This allowed us a clear view of a therapeutic course undertaken by an entire multidisciplinary team.

From a psychomotor point of view, a spinal cord lesion causes affected patients severe difficulties, as it destroys completely their perception of their body schema. This "new situation" requires a completely different therapeutic approach, because prognostic certainties are fewer and the therapeutic team has to respond to new requirements and can pursue objectives only as they become clear.

In this situation, treatment is more protracted and the patient often finds himself having to defer other aspects of his personal life, such as his return to work. These difficulties continue after the discharge of the patient, because the rehabilitative treatment has to be continued on an outpatient basis and "walking" often becomes the focus of the spine-injured person's entire existence.

Obtaining the maximum possible functionality is an unquestionable objective, but are operators ready to alter their therapeutic approach in order to tackle these new problems?

NEUROPSYCHOLOGICAL ASSESSMENT:
PRE AND POST TREATMENT EVALUATION
IN THE COGNITIVE REHABILITATION
OF DEMENTED PATIENTS

G. Grioni, S. Avanzi, E. Galante

Description of the cognitive deficits and on the spot, were unable to perform the tasks, but performed them after appropriate training. Therefore we suggest that locomotor responses in SCI patients may not be due to changes localized to limited regions of the spinal cord, but may depend on a plastic redistribution of activity across most of the rostro-caudal extension of the spinal cord. Distributed plasticity underlies recovery of foot kinematics by generating new patterns of muscle activity that are the motor equivalent of the normal ones. This hypothesis is reinforced by the fact that locomotor recovery does not transfer to untrained tasks. The locomotor programs encrypted in the reorganized networks allowed functional recovery of unsupported gait in most incomplete paraplegics, whereas they remained non-functional in most complete paraplegics outside the laboratory conditions, as these patients could not walk without body support.

NEUROPSYCHOLOGICAL ASSESSMENT:
PRE AND POST TREATMENT EVALUATION
IN THE COGNITIVE REHABILITATION
OF DEMENTED PATIENTS

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Diagnostic criteria for dementia require the presence of multiple cognitive deficits that include memory impairment and at least one of the following cognitive disturbances: aphasia, apraxia, agnosia, or a disturbance in executive functions. The cognitive deficits should be so severe as to interfere with the usual activities of daily living and to represent a decline in relation to previous levels of functioning. Given that cognitive deficits constitute the distinctive feature in the definition of dementia syndrome, a good assessment of cognitive function is fundamental not only in order to confirm the diagnostic hypothesis of dementia but also to identify both qualitative features useful in differential diagnosis and quantitative features useful for follow-up evaluations.

In some forms of dementia other than Alzheimer’s disease the appearance of memory disorder can be preceded by behavioural disturbances. These behavioural problems, as well as patient autonomy, seem to be strongly correlated to the perceived burden of care-giving, and therefore, a complete multidimensional assessment of demented patients should also include instruments for the quantitative evaluation of behavioural disturbances (see for example, the Neuropsychiatric Inventory - NPI) and functional independence measures (e.g., Instrumental Activities of Daily Living - IADL).
The above considerations seem to be especially valid when treating demented patients (pharmacologically or otherwise) and even more so when cognitive rehabilitation is planned. In patients with initial dementia, mild cognitive impairment (MCI) or other isolated cognitive deficits, an extensive neuropsychological evaluation is necessary, including both a screening test and complete cognitive batteries. In these cases psychometric results will be crucial in orienting the cognitive rehabilitation treatment, and provide data on which to base the subsequent evaluation of treatment efficacy. Furthermore, these data can be used in follow up for the measurement of the duration of treatment effects.

In the case of patients with moderate and moderate-to-severe dementia we recommend associating a screening test such as the Mini-Mental State Examination (MMSE) with more sensitive instruments like the Milan Overall Dementia Assessment (MODA) or the Mental Deterioration Battery (MDB), as more sensitive instruments may be better able to detect changes in patients’ cognitive performances.

As stated above we are convinced that each patient should also be administered a behavioural and functional scale in the pre and post treatment assessment in order to establish the possible effect of cognitive rehabilitation on these dimensions too.

Considerable attention should also be paid to the caregivers of demented patients, as these are the ones who bear most of the psychosocial and economic burden of dementia. Evidence to this effect has, in the past few years, led to greater consideration of caregivers as allies in the diagnostic and therapeutic process and to the development of interventions that address them specifically.

We also suggest that the caregivers’ perceived burden should be measured pre and post treatment through ad hoc scales (for example the Screen for Caregiver Burden or the Family Strain Questionnaire), particularly when they themselves are the target of a specific intervention.

In conclusion, a detailed and multilevel assessment of demented patients (and maybe of caregivers) pre and post treatment seems to us to favour the planning of cognitive rehabilitation programmes and to provide a reliable measure for the assessment of treatment efficacy.

COGNITIVE REHABILITATION IN ALZHEIMER’S DISEASE

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The approach to the rehabilitation of cognitive functions in patients with dementia, unlike what we have seen in relation to aphasia, head trauma and stroke, has been conditioned by a pessimism generated by the progressive nature of AD and correlated dementia and by the severe impairment of learning abilities in AD. Until a decade or so ago, attempts at rehabilitation in dementia were based on poorly defined theoretical presuppositions and methodologies that could often be summed up in the slogan ‘use it or lose it’. All this resulted in undifferentiated approaches, coarse evaluations and aspecific targets, which in turn gave rise to a rehabilitative practice inspired mainly by prosthetic models or aspecific global stimulation.

It is only recently that a body of experimental evidence – based on demonstrations of a sparing of procedural in relation to declarative memory – and also of clinical evidence has made it possible to develop interventions designed to slow down the cognitive decline that is characteristic of AD. Most authors agree that the possibility of obtaining significant results from the rehabilitation of AD patients is strictly dependent upon the stimulation of functions that are relatively spared, at least in the initial and intermediate stages of the disease. Experimental research also suggests that while the possibility of obtaining improved mnesic performances is reduced, it is not completely jeopardised; the difference between a normal elderly person and one affected by AD, at least in the initial stages of the disease, is in fact a qualitative rather than a quantitative one. The loss of cognitive faculties is not “all-or-nothing” but rather a gradual process that leaves room for a rehabilitative approach.

As dementia progresses, the possibility of using interventions that need to be supported by the patient’s internal cognitive strategies decreases, and there is a proportional increase in the role of behavioural and environmental interventions, both those that are selectively oriented towards mnesic and cognitive functions, and prosthetic ones, and these must be chosen on the basis of the residual resources, which will differ greatly from individual to individual.

There are many clinical manifestations that can be targeted by specific rehabilitative interventions and they concern cognitive deficits (memory, language, attention, and so on), sensory deficits and depressive symptoms, sleep-wake cycle alterations, eating disorders, motor deficits and activities of daily living. However, of these various ambits, only cognitive deficits, and in particular impairment of memory (of memories) in AD, have received the attention of researchers and clinicians. The various rehabilitative techniques are conditioned by the severity of the dementia: mnemotechniques, stimulation of procedural memory and reality orientation training are appropriate in the initial stages of the disease; reminiscence and remotivation therapy in the initial and intermediate stages, and validation therapy in the intermediate and advanced stages. Since the patient’s needs alter in the course of the disease, the rehabilitative approaches need to change to reflect this.

NEUROPSYCHOLOGICAL TRAINING WITH ELECTROPHYSIOLOGICAL CONTROL. WHAT DO WE KNOW?

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We submitted 10 elderly subjects to somatosensory training. Daily training sessions modulated amplitude of the N140 potential related to spatial attention. Indeed, this modulatory effect was observed only for N140 am-
Dementia is a very complex condition during the course of which cognitive, behavioural and functional aspects variously interact. Consequently, methodological instruments and outcomes of rehabilitative intervention are not easy to define as they vary in continuation according to the progression of symptoms. Neuropsychological measurement is obviously a stage that must precede the construction of the rehabilitative intervention and that is useful to assess the efficacy of the latter. Cognitive functioning can be applied to everyday life, as it is considered to be predictive of functional status, but evaluation of cognitive functioning must be integrated with performance-based assessment and family report, both fundamental in order to identify the precise targets of rehabilitation, particularly in the more advanced stages of the disease. The goals of rehabilitation in dementia must be realistic, established on the basis of an accurate evaluation of the patient’s residual abilities, and decided together with the caregiver.

The role of functional assessment and family report in the construction of rehabilitative interventions has been examined in several studies; discrepancies have been reported between these two types of measurement, as they probably evaluate different aspects of a patient’s functional status, and therefore their relative weight can change during the course of the disease. The profile of the individual caregiver, his/her burden in particular, is probably one of the factors most likely to influence family report even in mild dementia. Other aspects can interfere with the rehabilitative programme: behavioural disturbances and medical illness in particular, while very disturbing for patients and caregiver, do not seem to worsen functional ability.

**FUNCTIONAL ASSESSMENT AND FAMILY REPORT IN COGNITIVE REHABILITATION OF DEMENTIA**

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Dementia must be realistic, established on the basis of an accurate evaluation of the patient’s residual abilities, and decided together with the caregiver. The role of functional assessment and family report in the construction of rehabilitative interventions has been examined in several studies; discrepancies have been reported between these two types of measurement, as they probably evaluate different aspects of a patient’s functional status, and therefore their relative weight can change during the course of the disease. The profile of the individual caregiver, his/her burden in particular, is probably one of the factors most likely to influence family report even in mild dementia. Other aspects can interfere with the rehabilitative programme: behavioural disturbances and medical illness in particular, while very disturbing for patients and caregiver, do not seem to worsen functional ability.

**HOME MANAGEMENT OF GLOBAL AMNESIC PATIENTS**

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Global amnesia is characterised by impairment of most of the components of memory and frequently associated with a varying degree of diffuse cognitive deterioration and with behavioural disorders. In clinical practice and in rehabilitation, the patient affected by global amnesia thus presents with features that resemble to some degree those seen in the initial stages of degenerative brain disorders, without however showing the progressive worsening course that is typical of the latter. Experience shows that global amnesias, not being evolving pictures, have little scope for spontaneous recovery, while as regards their response to rehabilitative treatments, it teaches us that conventional rehabilitation of memory, while capable of producing positive results in subjects whose amnesic disorders are limited to one or to only few components of memory, does not produce improvements in the individual with global amnesia. However, global amnesias have proved able to learn information or procedures in an implicit manner, if presented the same task a number of times, and especially if this is done in a contextualised and familiar setting; they become increasingly skilled and rapid in the execution of this task, and eventually become able to perform it independently. The amnesic subject, therefore, benefits most from stimulation that is systematic, structured and externally guided, that prompts him to start the action, that controls him as he performs it, and that gives him all the necessary feedback (positive or negative depending on the situation) enabling him to complete the action. Through this kind of intervention, even a global amnesic can acquire growing areas of independence. Since achievement of this result is easier in proportion to the familiarity of the setting, the amnesic subject needs a family group that is willing to become involved in the rehabilitation process, which revolves around two main objectives: finding the best way of interacting with the subject and
finding the best way of favouring his growing functional independence. This rehabilitative process should thus incorporate the following stages:

1. observation and assessment of the global amnesic subject in a specialised centre;
2. definition of the rehabilitative project and programme;
3. training for relative/s or care-giver;
4. home re-entry and development of amnesic care and training to recover his/her independence in personal activities;
5. training and conditioning to recover amnesic’s independence in domestic activities;
6. training and conditioning to recover amnesic’s independence in external activities;
7. training and conditioning to recover amnesic’s independence in complex daily activities;
8. periodic supervision of methodological approach and obtained results.

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Disability of neurological origin necessitates complex care and rehabilitative intervention and the recovery process is characterized by complex medical and biopsychosocial needs. Team care can represent a practical way of responding to this broad array of needs in both post-acute and chronic conditions. Different skills are combined and coordinated in teamwork, wherein shared evaluation of problems and collective goal-setting add value to the rehabilitation. The strongest evidence of the importance of teamwork has come from analysis of the various components of stroke units, in which the multidisciplinary approach has been shown to be a fundamental factor. Good teamwork rests on cohesion of the group, sharing of rehabilitation targets, and on good leadership. Time and effort from all the members are needed in order to create an effective team, to build a working relationship and to foster a productive and positive atmosphere. Conflicts and disagreement are normal and may even be considered to contribute to the team development. A good rehabilitation team creates an atmosphere in which it is possible to agree and disagree without accusation. In order to do this, the team spirit has to be maintained through constant innovation of the approach adopted. Indeed, one of the main risks is complacency, situations in which the members of the team seem to have been doing the same things for years despite advances in the rehabilitation field. Continuous updating of knowledge should involve an evidence-based medicine approach. Teamwork has its cost, in fact team members are required to hold meetings, to develop good communication and to define the rehabilitation goals. The time spent on these activities might appear to be wasted, i.e., regarded as time that could have been spent on more lucrative activities such as physiotherapy sessions. However, the cost is more than offset if the effectiveness of the team approach is reflected in a decrease in mortality and disability of the patients. In view of these considerations teamwork should be included in the accreditation requirements of institutions that perform rehabilitation programmes.

ADVANTAGES AND PROBLEMS OF MULTIDISCIPLINARY WORK: CONCLUSIONS AND OPERATIONAL PROPOSALS


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The complexity of an individual’s needs and the ongoing evolution of scientific knowledge underlines the need for a multidisciplinary approach in rehabilitation, as in other areas. The Personal Rehabilitation Programme (PRP) is a fundamentally important unifying element, in which the centrality of the individual and of his needs becomes the responsibility of the team in charge of his care, whose task it is to identify the need for intervention of other clinicians and to arrange for the same. The PRP clearly revolves around the individual, considered globally, and it is crucial that each professional sees his role as an integral part of the whole project. Professional autonomy is without doubt an important aspect: it must be integrated into a team wherein the contributions and expertise of the different members increase in value the more they are correlated, shared and synchronised, etc.

The project must derive from a clear and shared view of attainable objectives and practical strategies, and define the programmes followed by the individual team members: the process of analysing and developing the peculiar aspects of the therapeutic intervention must come after the reaching of decisions and of an overall view, and not before. All the professionals involved in the rehabilitative process have in common a specific training in rehabilitation, a professional profile that identifies them and determines their competencies, their areas of autonomy and responsibility, and a deontological code to which they must adhere. Relations between the different members of the team must necessarily be based on equality and on recognition of the various areas of professional expertise.

It is up to the rehabilitative team to make organisational decisions, to make general choices relating to the therapeutic intervention and to assess the performance of its own members. The team is a dynamic, interactive reality, mutable in response to the patient’s needs. The rehabilitation record is the document, shared by all the members of the team, that, step by step, bears witness to the rehabilitative course and the process of recovery, allowing operators at a subsequent stage or level to be fully acquainted with what has been done and to plan future interventions.

The training and updating of rehabilitation professio-
nals, being designed to increase professional expertise and stimulate interdisciplinary dialogue among team members, is a factor that enhances their performance. The risks of interdisciplinary work are that roles may become too fragmented and the patient may – if the team’s intervention is not sufficiently coordinated and harmonious – receive too many different messages, and the tensions that a poorly organised and managed team can generate in its individual members could undermine the centrality of the individual. In short, the conditions for successful group work are:

- a small number of members
- careful selection
- scope for interaction
- a common language
- shared objectives
- integration
- ability to face up to difficulties.

All this in order to prevent excessive fragmentation of interventions from diminishing the single operator’s sense of responsibility towards the organisation, and depriving the patient of a clear figure of reference, both scientific and relational.

THE MOLECULAR ERA OF MYOLOGY:
NEW BIOMOLECULAR AND CLINICAL DIAGNOSTIC FINDINGS

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In the pre-molecular era, the classification of muscle diseases was based on characteristic clinical and/or microscopic pathological features. In the molecular era, the basis of classification has changed and is still evolving and includes: mutational characteristics, affected proteins, microscopic features, the nature of the abnormal cellular process(es), principal organelle involvement and distinctive clinical features. Three categories serve as the basis for molecular classification.

1. Mutational profile plus organelle involvement: a) primary sarcolemmal diseases involving the plasma membrane or basal lamina: dystrophinopathies, sarcoglycanopathies, merosin-deficient diseases, dysferlinopathies and caveolin-related diseases; b) diseases with primary myonuclear abnormalities: emerinopathies, lamin A/C-related diseases and myotubular related centronuclear myopathies; c) diseases with a primary involvement of myofibrils or cellular cytoskeleton: actinopathies, core diseases, nemaline myopathies, plectin and telethonin related myopathies, myosin heavy chain type 2 syndrome and desminopathy; d) diseases with ion channel or ion transporter defects: chloride/calcium/potassium sodium channelopathies (myotonic or other periodic paralyses), sarcoplasmic reticulum (SR) calcium release channel (ryanodine receptor) and SR ATPase-related myopathy (Brody’s disease).

2. Nature of the relevant cellular processes: a) muscle metabolism: catabolic metabolism, including lysosomal disorders (lamp-2 deficiency, α-glucosidase deficiency, and x-linked myopathy with excessive autophagy) and non-lysosomal disorders (calpainopathy and proteoso-mal disorders); carnitine and fatty acid metabolism; glycolytic pathways and mitochondrial oxidative phosphorylation defects; b) neuromuscular transmission: congenital myasthenic syndromes and autoimmune myasthenia gravis; c) glycosylation: inclusion body myopathy with GNE deficiency, muscle-eye-brain syndrome, and Fukuyama’s congenital muscular dystrophy.

3. Special complex molecular mechanisms: a) trinucleotide (CTG) repeat expansion: in DMPK (myotonin) gene in myotonic dystrophy type 1 (DM1); trinucleotide (GGG) repeat expansion: in PABPN1 gene (ocular dystrophy muscular dystrophy); tetranucleotide (CCTG) repeat expansion: in the gene encoding zinc-finger protein (ZNF9) in myotonic dystrophy type 2 (DM2); d) large telomeric deletion: on chromosome 4 in the D4Z4 repeat zone (fascioscapulohumeral muscular dystrophy).

Even in this molecular era of myology, the diagnostic process of muscle diseases must still start with obtaining a detailed history and performing a careful examination. The next steps are electrophysiologic studies and microscopic study of muscle biopsy using advanced histochemical and immunohistochemical analysis. These two approaches are sufficient to establish a diagnosis of a number of myopathies. However, since the gene mutations responsible for many muscle diseases have been discovered, protein and gene testing should be integrated into the standard patient diagnostic workup.

REHABILITATION IN ADULT MYOPATHIES

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Despite advances in the molecular genetics of myopathies, corresponding therapeutic tools are still lacking. Of the symptomatic treatments for myopathies, continuous physiotherapy is crucial in the maintenance of optimal subjective and objective conditions. A crucial question is the opportuneness of physical exercise programmes for these patients. It is still not clear whether muscle exercise is useful or dangerous, a problem very much complicated by the heterogeneity of muscle disorders.

Indeed, literature data appear difficult to interpret due to the extreme variability of muscle diseases and the lack of homogeneous protocols and diagnostic certainty, especially in the light of the rapidly growing potential for genetic diagnosis.

Now that science is progressing towards the application of revolutionary therapies (gene therapy, stem cell therapy…); we need muscle efficiency evaluation methods that are objective, non-invasive, easy to administer, re-
lial and exhaustive. We describe some such methods that might be applied routinely in muscular disease. **Assessment of exercise-induced muscle damage.** Skeletal muscle has a complex cellular and subcellular organisation that allows it to maintain its structural integrity even when it is subjected to stress, such as during a contraction. When the mechanical stress exceeds the fibre tension developed, the structural component suffers plastic deformation, and then breaks down. Raised creatine kinase (CK) serum levels are regarded as an index of increased membrane permeability and muscle damage. The myopathies, in particular the dystrophies, are characterized by CK release, and serum levels are often high. In our laboratory we use a protocol to evaluate fibre fragility in muscular dystrophy. The protocol consists of 15 minutes' walking on a treadmill at constant speed (the patient's maximum speed). During the exercise, heart rate is continuously monitored so as not to exceed maximal heart rate, theoretically calculated. CK plasma levels are measured at rest and 1, 3, 6 and 24 h after the conclusion of the test by venous blood samples drawn from the antecubital vein. This approach, objectively, is non-invasive, easy to administer, reliable, and without collateral effects. It is important to establish the best type and intensity of the exercise, i.e., to plan personalised rehabilitative programmes that will not cause further muscle damage. **Assessment of muscle oxidative efficiency.** Muscle contraction is due to the intracellular consumption rate of high energy phosphate, in particular ATP, and to its recovery. Both mitochondrial oxidative metabolism and anaerobic glycolysis produce ATP. Oxidative metabolic deficit causes altered contractile efficiency, early fatiguability and, in drastic conditions only, myofibre structural damage. Thus, assessment of oxidative metabolism is very important in the approach to myopathic patients. In our laboratory we designed an evaluation protocol to explore aerobic metabolism efficiency. The protocol consists of an incremental exercise performed on a treadmill. The test is subdivided into 11 stages of 2 min. duration, at a constant speed of 3 km/h. The gradient is 0° at the beginning and incremented 2.5% at each stage. If the subject reaches 75% of maximum heart rate, theoretically calculated, the test is stopped. In this way the work is kept in a predominantly aerobic condition. Haemostatic lactate is assessed by venous blood samples collected at rest and at 1°, 5°, 10° and 30° after the end of the exercise. This objective tool allows us to monitor improvement of oxidative efficiency by aerobic training in diseases with a metabolic genesis of the muscular fatigue phenomenon, such as mitochondrial myopathy and probably also inflammatory myopathies. **Localised muscle fatigue.** Over the past few years, the importance of the surface myoelectric signal to qualitatively and quantitatively understanding of muscle physiopathology has been demonstrated. During sustained contraction, the metabolic processes and changes in sarcolemma ion permeability produce alterations in the action potential amplitude, shape and width, which are paralleled by changes in the surface myoelectric signal. Quantitative indicators of such changes are estimates of the conduction velocity (CV), the median frequency of power spectrum (MDF) and amplitude variables such as the average rectified value (ARV). In our laboratory we apply a protocol characterized by a stimulated contraction and a surface EMG recording. Stimulation consists of 30-sec, 35 Hz pulse trains, 0.1 msec in width. CV and MDF parameters give information about mean fibre size and fibre-type ratios. ARV provides information on myofibre number and sarcolemmal excitability. In conclusion, the availability of quantitative indicators of the phenotypic expression of muscle involvement can be directly exploited, through a variety of non-invasive and repeatable methods and could constitute a powerful approach for assessing the efficacy of both physical and/or pharmacological treatment strategies in myopathies. **VERBAL DELAYED REACTION TIMES UNDER DIFFERENT DEGREES OF TIME PRESSURE**

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The neural substrates of actions characterized by considerable emotional participation on part of the patient involve functional influences between the pre-frontal cognitive system and the limbic circuits where the emotional components are generated and integrated. The outcome of stressors on the subject's performance can be highlighted through tests requiring selective and goal-oriented attention, such as verbal delayed reaction verbochronometry. Twenty-three normal subjects were investigated, divided into two age groups (18-44 and 60-75 y.o.); each group was also divided after an interview investigating motivation to perform the test and perception of the task as a possible stressor. Immediate and delayed reaction tasks (0.5 and 1.5 s foreperiods) were performed to study the facilitation processes depending on recurrent internal circuits. Moreover, the interference stimulus of a 0.1 s foreperiod was also included to study collateral inhibitory processes. 72 reactions were recorded for each trial and three different trials were performed in each subject: basal condition, with no incitements; mild time pressure, with an oral incitement every 12 reactions; high time pressure, with incitement and rebukes given every 4 reactions. An interval of at least 3 days was allowed between each trial. In the immediate reaction task we found no differences between stressed and non-stressed subjects in the basal condition, while a significant decrease (~18%) was found in both stressed and non-stressed young subjects in the mild time pressure condition; instead, under the high time pressure condition, markedly increased reaction times occurred only in the stressed subjects (+25%), both young and old. In the 0.5 and 1.5 s delayed reaction tasks the ratio increased significantly from 0.7 to 0.8-1.0 value in young subjects, both stressed and non-stressed, and in both the mild and the high time presu-
The poor development of control activity in the absence of procedural learning forces patients to potentiate attentional strategies in order to compensate for their procedural learning impairment. SPT shows that patients modify their electrophysiological patterns regaining the ability to use more automatic learning strategies.

DIACHRONIC STUDIES WITH DELAYED REACTION IN PARKINSON’S DISEASE

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In previous studies (1993, 1994) we evaluated how akinesia, rigidity and tremor influence psychomotor performance in Parkinson’s disease (PD), and demonstrated significant impairments of psychomotor reaction latency time in akinetic-rigid subjects and in iatrogenic parkinsonian patients. These preliminary studies have been extended to 67 akinetic-rigid parkinsonian patients, 4 of whom were subsequently re-tested with serial controls up to 14 months after treatment with levodopa-decarboxylase inhibitors (LD+DI). The most striking finding was the increased tR,a (latency time of simple reactions), which was equal to tR,ab (latency time of choice reactions), the values of which did not change significantly at the re-test.

The duration of the acousticogram response (D.ACG) was not significantly increased at baseline and showed a marked reduction at the re-tests up to the 10th month. At baseline the ratio of immediate to delayed reaction latency time (tRim/tRd) was increased particularly for the shortest foreperiods (0.1, 0.5, 1.5 sec) at the re-test at 2 months, while it was almost normal for the foreperiods of 4 and 10 sec.

At baseline the most evident alteration was in the trials of 100 serial self-paced reactions:
1) the self-paced latency time of the acousticogram (tACG) was longer than D.ACG of reactions with computer-induced stimuli;
2) the mean interval was increased, double the normal length, with a progressive slowing of the frequency of reactions;
3) the pauses were more frequent and longer.

In the re-tests we found, at 2 months, a 22% reduction of the mean interval and length of the pauses, and following this an inversion of the mean interval and length of pauses, with a significant increase compared to baseline at 10 and 14 months.

These findings, even though limited at present to the follow up of 4 cases, point to the sensitivity of this method in evaluating the course of PD, just as previously we demonstrated a correlation between multiple delayed reaction verbochrorometry (MDRV) and clinical severity. Moreover the latest refinements to our methodology have enabled us to show the particular sensitivity of the “protracted attention” test in the sequences of 100 self-regulated trials.

These longitudinal studies, if confirmed, will make it possible to measure the positive effects of a pharmacological treatment – LD+ID or dopaminergic agonists – in particular on the duration of responses, possibly provi-
BRAINCASE TRAUMA IN WORKING ACCIDENTS

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A considerable number of victims of braincase trauma sustained in working accidents were submitted to multiple delayed verbochronometry (MDRV) investigation at the headquarters of INAIL in Cremona, Italy. From these subjects we selected 10 patients between 20 and 50 years of age who had required intensive care for at least I-3 days and who did not show any significant psychomotor or cognitive residual damage upon clinical investigation using the usual methods.

In MDRV, a word seen on the screen is the stimulus and it must be read immediately, giving an immediate reaction (Rim). The latency and duration of both the acoustogram (ACG) and the orbicularis oris muscle responses are easily measurable (EMG). The delayed reaction (Rd) is obtained following a stimulus that appears at different intervals (Pp of 0.1-0.5-1.5-4 sec.) and orders the subject to read the word aloud. The Rd is studied in the same way as the Rim. The results show prolongation of the Rim latency. In particular, in comparison with the mean normal ACG latency (450 ms), we obtained the following Rim latency values:

– around 500 ms: 4 patients.
– between 500 and 600 ms: 2 patients.
– between 700 and 800 ms: 2 patients.
– between 800 and 900 ms: 2 patients.

Important alterations were recorded in Rd for Pp of 0.1 sec.: the ACG latency showed a further increase of 30-40%.

Finally, we recorded a moderate tendency towards normal values for Rd in the higher Pp.

The latency and length of EMG and ACG are not discussed.

The uniform prolonged latency of Rim and the difficulty of inhibiting the interfering stimulus with a partial preservation of the perspective memory appear important aspects.

EFFECTS OF TRANSCRANIAL MAGNETIC STIMULATION ON VDRM PARAMETERS

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Transcranial magnetic stimulation (TMS) is a recently developed tool for in vivo neurophysiological evaluation of the motor cortex. This technique produces a transient high-intensity magnetic field that allows transsynaptic activation of cortical motorneurons, whose responses could be recorded from both the spinal cord and muscle.

In recent years repetitive transcranial magnetic stimulation (rTMS) has become a useful tool for investigating and even modulating cortical excitability being able to determine plastic changes that can inhibit (LTD) or facilitate (LTP) the motor cortex. Moreover, rTMS, using different parameters (short trains of high-frequency stimulation at intensities over the motor threshold), could determine a transient disruption of the stimulated areas.

VDRM is a simple and practical tool for studying immediate and delayed verbal reactions. The prefrontal cortex is involved in a number of planning and decision tasks but only few cortical areas have been demonstrated to have a specific function.

In this study we used the Verbal Delayed Reaction Methodology (VDRM) to evaluate the effects of disruption of the prefrontal cortex on verbal reactions in normal subjects.

The possibility of selectively modulating the function of cortical areas makes the rTMS a useful tool that promises to further understanding of the process involved in verbal reactions.