The Rehabilitation of Executive Disorders

A Guide to Theory and Practice

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To Ann (M.O.)

To Lara for being there, to Stephie and Amber for just being (A.W.)

10

Physiotherapy approaches with people with executive disorders

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The executive system: living up to minimum requirements

It has been suggested that humans evolved as hunter–gatherers who needed to store food in times of plenty so that they could meet their energy requirements and avoid starvation in times of famine (Neel 1962). In the modern world, sedentary man has constant food accessibility and the so-called 'thrifty gene' leads us to become unhealthily obese through lack of exercise. Fortunately, our species is equipped with executive abilities which, in theory, can override our propensity to overeat and under-exercise. Ideally, our frontal lobes should play the role of the super-ego and tell us to restrict calorie intake in accordance with decreasing calorie expenditure or, conversely, to increase calorie expenditure to counter excess dietary calories.

Unlike other mammals that are prone to the detrimental effects of being overfed and deprived of exercise, *Homo sapiens* has the executive capacity to plan ahead, inhibit or initiate behaviour, and revise plans that are already formulated, and thus potentially has the ability to ward off health hazards. However, innate laxity and social conventions often get the better of the endeavours of the frontal lobes to adjust behaviour in time, as evidenced by the epidemic increase in lifestyle-related diseases.

People who sustain brain injuries are often at a double disadvantage. They may have motor deficits which make exercising even harder and they may have executive deficits. If an ever-increasing number of people find it virtually impossible to take adequate exercise and maintain a stable weight, any executive disorder arising from acquired brain injury (ABI) will act as a further impediment to meeting the recommended daily quota of exercise, i.e. a minimum of 30 minutes of moderate-intensity exercise per day and 1–2 hours of moderate- to high-intensity exercise per week. Experts unanimously advocate a minimum weekly leisure time calorie expenditure of 2000 kcal (8400 kJ), preferably at an intensity exceeding 6 kcal/minute. Those who have suffered a brain injury resulting in difficulties with impaired self-awareness, modulating behaviour, initiating and inhibiting, planning, and structuring their time are even less likely than the rest of us to engage in adequate levels of exercise, In addition, an ABI may result in motor sequelae that prevent physical activity at any intensity but the lowest. For those with less severe motor impairment, slower movement patterns and fatigability will lead to lower calorie expenditure per minute.

Physical consequences of ABI

People suffering from stroke are far more likely to sustain severe physical disability than those with traumatic brain injury (TBI). Three months after stroke, 20 per cent of patients remain wheelchair-bound, and approximately 70 per cent walk at reduced velocity and capacity (Bohannon *et al.* 1988). Common long-term physical consequences after stroke include hemiparesis leading to varying degrees of loss of volitional movement patterns, muscle strength and dexterity, muscular endurance, and speed, as well as balance and efficient motor planning. Although very few TBI patients continue to remain wheelchair-bound, there was little change in mobility between 2 and 5 years after injury in a sample of TBI patients (Olver *et al.* 1996). Five years after injury, 41 per cent continued to have difficulties with activities requiring higher-level balance skills, such as running and jumping. Sixty-seven per cent of the sample reported that they fatigued more easily on physical exertion than prior to their accidents. Common long-term physical consequences after TBI include epilepsy, dizziness, headaches, and visual difficulties at 5 years after injury (Olver *et al.* 1996). Other physical consequences are ataxia, dysco-ordination, and motor-sequencing problems, as well as sequelae after fractures. All these physical consequences of stroke and TBI lead to impaired mobility and reduce not only the overall level of physical activity, but also the muscular and cardiovascular intensity with which every single physical activity throughout every single day is performed.

Although the extremities contralateral to the side of the lesion are usually referred to as the affected side, there is evidence that the side ipsilateral to the lesion is also affected to some extent. The acute effects of hemiparesis and impaired balance are often exacerbated by an ensuing period of prolonged hospitalization where not only fatigue and post-injury depression, but also

inadequate rehabilitation resources contribute to additional decline in strength and endurance. With more hours spent lying in bed or sitting than was the case premorbidly, and with the only active periods of the day being defined and structured by the therapist in charge, it is no wonder that patients tend to become very dependent on their therapists, and that many patients come to look upon rehabilitation as a matter for specialists rather than as an area where they can play a very responsible role by simply boosting the process through their own level of activity.

In an ongoing study conducted at the Centre for Rehabilitation of Brain Injury (CRBI) in collaboration with the Copenhagen Muscle Research Centre (CMRC), muscle biopsies taken from hemiplegic stroke and TBI patients have proved to differ significantly on the affected side compared with the less affected side. The preliminary results show an overall tendency towards a breakdown in muscle fibre symmetry, size, and distribution on the affected side. In the largest muscles (i.e. the leg muscles), endurance is essential for standing and walking, and so a high percentage of enduring fibre types I and IIa is crucial for normal endurance and safety. However, the research at the CRBI has demonstrated that the shift in fibre types is reversible to a significant degree if the patients engage in heavy progressive resistance training three times a week for a 12-week period. Not only does this kind of training improve the strength of the affected muscles, the peak rate of force development (RFD), and the twitch peak torque (i.e. the neural ability to produce a full muscle contraction quickly), but the acquired strength translates into significantly improved walking speed and gait quality.

The advantages of exercise and goals of physical rehabilitation after ABI

The ultimate goal of any rehabilitation process must always be to bring about optimum restoration of function, thus permitting the patient to revert to independent living and regular physical activity with as little assistance as possible. A retrospective study by Gordon *et al.* (1998), in which 240 individuals with TBI (64 exercisers and 176 non-exercisers) and 139 control individuals without a disability (66 exercisers and 73 non-exercisers) were compared on scales measuring disability, handicap, depression, and self-perceived symptoms categorized as cognitive, concluded that not only were the TBI exercisers significantly less depressed than the non-exercisers, but they also perceived themselves as having significantly fewer cognitive problems and significantly better health status than the TBI non-exercisers. This finding was despite the fact that there were no differences between the two TBI groups on measures of disability and handicap. Significantly more cerebral lesion patients than cranial fracture patients found emotional control more difficult, as well as having increased difficulties with memory and concentration, maintenance of leisure time interests, and general life satisfaction (Engberg and Teasdale 2004). Minimizing the sense of loss of leisure time interests and social integration through attainable and easily appreciable physical improvements is a very effective way of boosting self-efficacy.

Many studies (e.g. Weiss *et al.* 2000; Teixeira-Salmela *et al.* 2001) have clearly demonstrated that high-intensity muscle strengthening and physical conditioning are superior to more conventional physiotherapy, not only in terms of earlier discharge, but also in terms of attaining better functional performance outcome. Many physiotherapists and occupational therapists have had reservations about resistance exercise, and many still do. Reputedly, weight training cannot transfer to functional improvements and is thought to exacerbate hypertonia and provoke abnormal movement patterns. These fears have proved to be groundless in a large number of studies, many of which are cited in a very thorough review article (Patten *et al.* 2004). Intensity is of vital importance, and this also applies to the increasingly popular techniques of treadmill training with or without body weight support (Hesse *et al.* 2001; Pohl *et al.* 2002). The question no longer seems to be which physiotherapy approach is the most effective, but how to maintain functional outcome levels over time after discharge.

The sedentary threat

Many people with ABI have a potential for improved mobility, ranging from independent ambulation and/or increased walking velocity and capacity to regaining the ability to run. The prerequisite for achieving such improvements is to challenge the cardiorespiratory and musculoskeletal systems at levels where the challenge actually makes a difference. However, this prerequisite is not always evident to therapists and caregivers, let alone to the patients themselves. Consequently, almost all rehabilitation of motor function is carried out at a submaximal level, where the termination of a rehabilitative session is defined by the therapist running out of time rather than the patient reaching his/her limit and needing to rest. Cardiorespiratory training without the use of a heart rate monitor will leave both therapist and the patient in the dark with regard to the level of exertion, and will not supply vital and motivating information about a lower heart rate and energy expenditure during a given activity as a result of the beneficial effect of intensive cardiovascular training. Strength or resistance training without prior knowledge of maximal strength defined as 1 RM (one repetition maximum) will be diluted to simple programmes of certain sets of exercises repeated a certain number of times, not because this is the very best the patient can do this day, but because the number

of repetitions fits into the regimen or the time frame for the rehabilitation session. Exercises tend to be repeated in series of three sets of 15 repetitions because this number has become ingrained in physiotherapy. If patients doing 3 × 15 repetitions were asked to do two or three times as many repetitions, many would easily be able to do so, but precisely for that reason the exercise cannot be defined as actual strength training (Patten *et al.* 2004). If a given exercise can be performed well more than eight to ten times it begins to lose its strengthening effect. The more repetitions that can be performed in one set, the smaller is the gain in actual strength. This is common knowledge in athletics and in any serious strength training programme for healthy individuals, but apparently does not apply in most physiotherapy approaches for neurological patients. In the absence of basic knowledge of their cardiovascular and muscular performance levels, and lacking the necessary resources to remedy potentially remediable deficits, many brain-injured individuals run the risk of spiralling downwards in what can be termed a 'vicious circle of inactivity' (Figure 10.1).

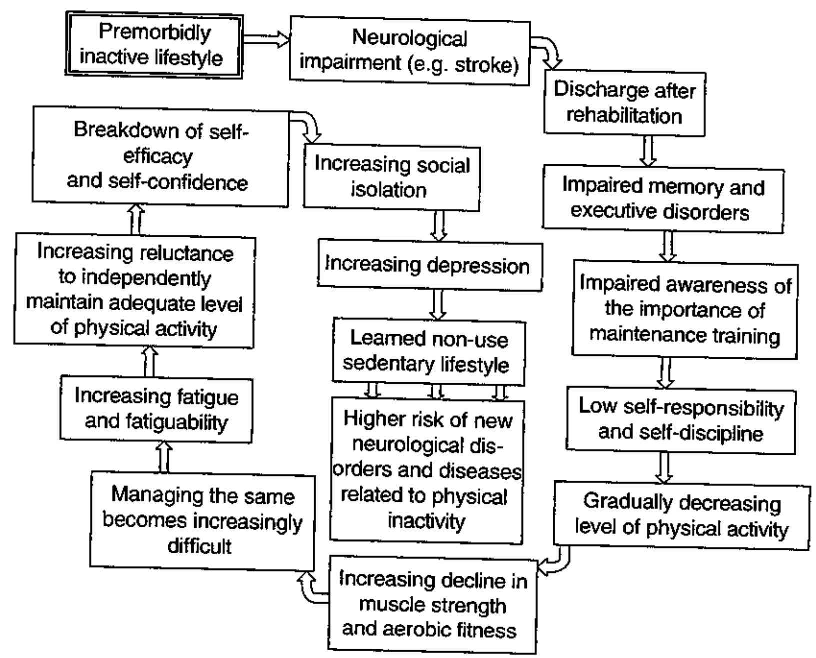

Fig. 10.1 The vicious circle of inactivity. A premorbidly inactive lifestyle may lead to stroke which, in turn, may lead to an even lower level of physical inactivity, thus further increasing the risk of new neurological disorders and other diseases related to physical inactivity.

Although first coined by Edward Taub (Knapp *et al.* 1958) to describe the tendency of hemiplegic patients not to use the affected upper extremity, the term 'learned non-use' is equally applicable to non-use of the cardiovascular system, cognitive faculties, and social skills, as well as of meaningful leisure-time activities and language. Faced with the punishing experiences of unsuccessful attempts to perform at the premorbid level, many people with ABI resign themselves to inactivity or even apathy in domains where they used to be active and engaged.

Benefits of physical activity: relevance to rehabilitation

Data from animal studies have indicated that exercise promotes brain vascularization, neurogenesis, and neuronal survival, and helps to resist brain insult (reviewed by Cotman and Berchtold 2002). There is also a positive relation between exercise and levels of brain-derived neurotrophic factor (BDNF), a protein with neurotrophic and neuroprotective properties which may be linked to brain plasticity (Cotman and Berchtold 2002). The levels of neurotransmitters, such as serotonin and dopamine, are also increased as a result of exercise (e.g. Blomstrand *et al.* 1989).

The research on humans is consistent with the results of the animal studies that provide evidence of the beneficial effects of exercise on cognitive functioning. In a meta-analysis of longitudinal intervention studies in adults over the age of 55, Colcombe and Kramer (2003) reported that fitness training in older adults increased performance on different cognitive tasks by an average of 0.5 SD compared with control groups. Executive control tasks appeared to benefit the most from the exercise. Frontal regions of the brain may be more likely to show improvements with exercise. Deficits in executive functioning, together with decreased processing speed and a decline in short-term memory, are among the most common cognitive consequences of TBI. Therefore it follows that exercise has the potential to promote brain repair in patients with brain injury, and in fact evidence of cognitive improvements following motor enrichment after brain injury has been found in both animal and human studies (reviewed by Kleim *et al.* 2003).

Physical activity is probably the domain where appreciable improvements can be achieved most rapidly in brain injury rehabilitation. Given the many difficulties that face both therapists and patients in the long process of establishing a therapeutic alliance and compliance that can pave the way for awareness, insight, and adaptation to a new life, it is often an advantage to embark on this process by exploiting the latent possibility of increased endurance, strength, and mobility. A general feeling of well-being leading to improved mood and malleability can often be observed after a physical training session where the brain-injured person really challenges the cardiorespiratory system and consequently becomes out of breath and begins to sweat. Nevertheless, brain-injured persons are very rarely seen to sweat or pant during physiotherapy.

People with acquired brain injury, and especially those with executive disorders, will often seem reluctant to put in an effort during rehabilitation. Where this is compounded by problems with drive, alertness, and initiative, cognitive-behavioural rehabilitation methods have been shown to be effective in increasing engagement in physical therapy (Worthington *et al.* 1997). Often, however, executive disorders such as lack of initiative, distractibility, and impulsivity are misinterpreted as a lack of motivation. While in some rare instances this may be true, what has been put down to lack of motivation on the part of the patient can often be traced back to the therapist who has failed to be sufficiently motivating or has omitted to explain the purpose and goal of the activity. If a patient does not see the relevance of an activity during a rehabilitation session, the cognitive and executive difficulties may be to blame, but the reason may just as well be that the activity lacks the intensity to result in any of the beneficial after-effects of physical exertion. The greater the difficulties with attention, concentration, and memory, the greater is the need for charting all training results in order to ensure cooperation with regard to an effort level that exceeds that of the previous session and to ensure motivation for improving performance. Adhering to a chart and exerting oneself to reach a preset goal that has been set by oneself and the therapist in conjunction can be very helpful in curbing impulsivity and staying on the track. This will be described in greater detail later in this chapter.

The ultimate goal of physiotherapy after ABI

Successful physical rehabilitation should endeavour to arrest the patient's gradual descent down the spiral by addressing all domains that are prone to the development of learned non-use. Skilful performance of any motor task has as a prerequisite adequate muscle strength and cardiovascular endurance. Without these fundamental physiological capacities the motor task in question will be doomed to meet with failure, poor performance, or early interruption. Given the limited resources available for rehabilitation of people with ABI, the more time spent on skill acquisition, avoidance of excessive tone, stretching, and other elements of conventional physiotherapy (e.g. Bobath-oriented Neurodevelopmental Treatment (NDT), Movement Science, and Proprioceptive Neuromuscular Facilitation (PNF)), the less time will be available to address the fundamental issues of strengthening and conditioning. Unless the patient is an athlete or has other previous experience from intensive training, it is very unlikely that he/she will have the courage to challenge dogma and to demand a training regime that focuses on cardiorespiratory conditioning and progressive resistance training, both of which are crucial in countering the deleterious effects of immobilization. Therapists and patients alike may rejoice in improved task performance, but many therapists know only too well that the correct performance of a task is short-lived to the point where the patient will revert to his/her compensatory strategy or inactivity as soon as the therapist's back is turned. Although this phenomenon is often referred to as lack of motivation or insight on the part of the patient, the truth of the matter may very well be that what the patient actually lacks is muscle strength and cardiovascular endurance to maintain 'correct' movement patterns for more than a brief period.

Tests and assessments

Apart from obvious research purposes, using relevant physical tests and assessments serves the dual purpose of motivating the patient to improve performance while at the same drawing the therapist's attention to resources and deficits in a quantifiable way.

Given the wide range of physical sequelae that can be observed in the wake of ABI, validated and reliable tests may not be available or applicable in all cases. Simple basic tests of fitness, endurance, strength, and walking speed that are easy to administer and reproduce offer patients and therapists a common ground for motivation, a good working alliance, and patient compliance. Without knowledge of the initial baseline levels of the above parameters, neither patient nor therapist will have any objective measure of functional gains, and consequently they will invariably resort to subjective and anecdotal interpretations of subtle improvements that may have qualitative relevance, but hardly ever reflect the concomitant quantitative improvements.

While relevant for research purposes and in the overall assessment of outcome, scales such as the Functional Independence Measure (FIM) (Keith *et al.* 1987), the Motor Assessment Scale (MAS) (Carr *et al.* 1985), the Fugl-Meyer Scale (Fugl-Meyer *et al.* 1975), the Berg Balance Scale (Berg *et al.* 1989), and the Action Research Arm Test (ARAT) (Lyle 1981), to name but a few, are all validated and reliable but are far too complex to be interpreted by patients and therefore are unsuitable for enhancing patient motivation. Testing and charting progress made in the number of times one can perform sit-to-stand, the time it takes to dress, the number of flights of stairs that can be climbed in, say, 5 minutes, or the maximum walking speed are far more likely to challenge the patient and to produce the incentive to put in an extra effort.

Relevant physiotherapeutic tests in brain injury rehabilitation

$VO_{2\,max}$ or cardiorespiratory endurance can be estimated in most neurological patients by using the submaximal 'Åstrand stationary bicycle test' (Åstrand and Rhyming 1986). Some patients may be so deconditioned that even the lowest workload allowed in this test (50 W) leads to exhaustion before reaching a steady state heart rate. Other patients cannot reach the required minimum steady state heart rate because of β-blockers. In both instances, the Borg Rating of Perceived Exertion (RPE) (Borg 1962) can offer valuable information with regard to the interpretation of the test result. A high correlation exists between a person's perceived exertion (range 6–20) multiplied by 10 and their steady-state heart rate during physical activity (Borg *et al.* 1987). If a person's maximum heart rate has been lowered by medication and therefore does not reflect the observable level of exertion (i.e. the person is panting and sweating whilst the heart rate remains low), the perceived exertion rating may provide a fairly good estimate of what the heart rate would have been during the same activity had it not been for the medication. For example, if a person's RPE is 15, then it may be assumed that the heart rate would have been approximately 150 beats/minute, although the heart rate monitor is showing 110 beats/minute.

Strength and endurance can be assessed by using a modified version of the Harvard Step Test where any change in the number of steps taken during 5 minutes as well as any drop in the total amount of heart beats counted after completion of the test will indicate improved strength and endurance. The official version of the Harvard Step Test can rarely be administered since it requires the subject to climb up and down a high step or box (usually 40 cm for women and 50 cm for men) 30 times per minute for 5 minutes, without any support. However, if a lower step height, fewer steps per minute, and support are allowed, almost anyone who can stand with support can perform the test.

Maximum walking speed can be measured with the 6-minute walk test (Guyatt *et al.* 1985) and compared with reference values for healthy subjects (Enright and Sherrill 1998), and with the 10-metre walk test (Wade 1992), which, although it overestimates walking speed (Dean *et al.* 2001), gives a very good impression of the fastest safe walking speed over short distances.

Grip strength can be evaluated with the Jamar dynamometer and compared with reference values for healthy subjects (Bohannon *et al.* 2006). Manual dexterity can be assessed with the Grooved Pegboard Test with reference values for healthy subjects (Ruff *et al.* 1993). With a little ingenuity, simple tests can be devised and charted for any physical impairment.

Brain injury rehabilitation at the CRBI

The Centre for Rehabilitation of Brain Injury (CRBI) at the University of Copenhagen was founded by Dr Anne-Lise Christensen in 1985. Since then, it has expanded considerably, but it still offers a neuropsychologically based holistic interdisciplinary 4-month outpatient rehabilitation programme for adults with ABI, followed by an 8-month follow-up period, the aim of which is return to education or gainful employment at some level. The day programme caters for people aged between 17 and 65 years. The programme is highly individualized, and can be extended from 4 to 6 or 8 months at a lower intensity if fatigue is an impediment to full-day attendance. As an integral part of the programme all patients (who are called students at the CRBI) are assigned to physiotherapy in accordance with their requirements. Prior to entering the programme, all students undergo a thorough neuropsychological investigation and a thorough examination by a special education teacher. Students with aphasic or dysarthric difficulties are also examined by a speech and language pathologist. All students are also required to undergo a 2-hour physiotherapeutic examination in which conventional tests play a negligible role since these tests are unable to provide new information, and because it is important from the very first meeting between student and therapist to stress the fact that the physiotherapeutic intervention at the CRBI emphasizes strenuous training rather than treatment. For the same reason, all sessions involving physical rehabilitation are called physical training, rather than physiotherapy or treatment.

Physiotherapy approaches at the CRBI: the initial examination

All rehabilitation must begin with thorough assessment. Conventional physiotherapeutic tests of abnormal tone and reflexes, reduced range of motion (ROM), compensatory movement patterns, adverse neural dynamics, etc. cannot supply any information pertaining to the present level of fitness and strength.

The physiotherapeutic examination at the CRBI always begins with an interview of 30–45 minutes, the purpose of which is to map self-perceived physical sequelae including pain, fatigue, etc., previous and present treatment, premorbid and present level of physical activity, and present wishes and goals. The next part of the physical examination (in order of administration) focuses on:

- resting blood pressure and heart rate
- enquiry into blood lipids
- prescription medication
- smoking and dietary habits
- grip strength
- dexterity
- dynamic balance
- body weight and calculation of BMI
- $VO_{2\ max}$ or cardiorespiratory endurance
- overall strength and endurance
- maximum walking or running speed.

All results of the examination are discussed with the student. Getting the student engaged in realistic goal-setting begins with conveying information and feedback at whatever level is permitted by his/her cognitive status. At the initial examination almost all students have poor endurance and strength, and suffer from fatigue and fatiguability as well as elevated blood pressure despite medication. Consequently, special attention is given to feedback regarding cardiorespiratory endurance and strength findings. These are presented candidly yet empathically with reference to official best-practice guidelines and outcome data from previous students at the CRBI. The physiotherapist describes the student's potential for improvement and the likely impact of such improvements on successful return to employment, independence in activities of daily living (ADL), and meaningful leisure-time activities including safe and independent ambulation. Most students are surprised at their low levels of endurance, which are already evident during the 6–9 minutes submaximal bicycle test and even more during the modified Harvard Step Test. Their spontaneous reaction is often that they have not been this much out of breath since their brain injury. Another common reaction is one of frustration at having been allowed to decline so dramatically during acute and post-acute rehabilitation. This mixture of surprise and frustration forms the ideal basis for setting goals and, if necessary for compliance, drawing up a contract with the student. Two to four days after the initial test, many students still experience delayed onset muscle soreness (DOMS) from the unaccustomed and strenuous activities and this serves as a lingering reminder of the goals set.

All initial tests are repeated at the end of the rehabilitation programme.

Two different physical interventions at the CRBI

People referred to the CRBI for rehabilitation fall into two categories:

- those referred for more specific purposes, e.g. speech and language, individual psychotherapy, or intensive gait training
- those referred for full participation in the interdisciplinary day programme.

The CRBI gait rehabilitation programme

People with significantly impaired gait or no independent ambulation can be offered an intensive 12 week gait rehabilitation programme either as a pre-programme or, if they do not meet the inclusion criteria for the full programme (e.g. because of age or substantial cognitive deficits), as a purely physiotherapeutic intervention. The 12-week gait programme consists of five weekly 90-minute sessions that take place in the CRBI gait lab. The structure and progression of this programme (Figure 10.2) has been developed in collaboration with researchers at the CMRC. Although drawing on inspiration from existing literature on body-weight-supported treadmill training (BWSTT), the CRBI model differs from other similar programmes not only in the duration of each session, but also in its highly structured use of high-intensity progressive resistance training (PRT) for the affected lower extremity. Every session begins with approximately 30 minutes of BWSTT at continuously increasing speed and incline gradient, with gradually deceasing harness support. On Mondays and Wednesdays the next hour is scheduled for high-intensity cardiorespiratory training in various machines, and on Tuesdays, Thursdays, and Fridays PRT is on the schedule. The PRT machines are equipped with visual feedback with regard to range of motion, movement speed, immediate watt-output for each repetition and average watt-output for each set. All training results are saved on individual USB memory keys which, after transfer of training results to the computer, are re-programmed for the following day. In this way, all machines are re-programmed for new adjustments and challenges. To ensure optimum engagement, the students undergo various gait tests every Monday, and they are given printouts which graphically illustrate their progress as well as relevant training results. Since many of those participating in this intervention are more cognitively impaired and have more executive disorders than students in the full CRBI day programme, a very rigid structure is essential to ensure motivation and compliance. Several students in this group have been wheelchair-bound for up to 2 years, and if the goal is to regain the ability to transfer and walk independently and safely, albeit usually with a cane or walker and wearing an ankle–foot orthosis, there is

The CRBI G.A.I.T. Program – 1½ hours per day for 60 days				
Cardiorespiratory and functional training	BWSTT + progressive resistance training 3 × 12 reps	Cardiorespiratory and functional training	BWSTT + progressive resistance training 3 × 12 reps	BWSTT + progressive resistance training 3 × 12 reps
Tests				
		Week 2		
Cardiorespiratory and functional training	BWSTT + Progressive resistance training 3 × 10 reps	Cardiorespiratory and functional training	BWSTT + Progressive resistance training 3 × 10 reps	BWSTT + Progressive resistance training 3 × 10 reps
Tests				
Compliance rating		Week 3		
Cardiorespiratory and functional training	BWSTT + progressive resistance training 4 × 8 reps	Cardiorespiratory and functional training	BWSTT + progressive resistance training 4 × 8 reps	BWSTT + Progressive resistance training 4 × 8 reps
Tests				
		Week 4 - Theme week		
BWSTT + stair climbing	BWSTT + gait training	BWSTT + stair climbing	BWSTT + gait training	BWSTT + Walkathon (as far as possible in 30 mins)
Tests				
		Week 5		
Cardiorespiratory and functional training	BWSTT + Progressive resistance training 4 × 8 reps	Cardiorespiratory and functional training	BWSTT + Progressive resistance training 4 × 8 reps	BWSTT + Progressive resistance training 4 × 8 reps
Tests				
		Week 6		
Cardiorespiratory and functional training	BWSTT + Progressive resistance training 4 × 8 reps	Cardiorespiratory and functional training	BWSTT + progressive resistance training 4 × 8 reps	BWSTT + progressive resistance training 4 × 8 reps
Tests				
		Week 7		
Cardiorespiratory and functional training	BWSTT + progressive resistance training 12,10,10,8 reps	Cardiorespiratory and functional training	BWSTT + progressive resistance training 12,10,10,8 reps	BWSTT + progressive resistance training 12,10,10,8 reps
		Week 8		
Cardiorespiratory and functional training	BWSTT + progressive resistance training 10,8,8,8,6 reps	Cardiorespiratory and functional training	BWSTT + progressive resistance training 10,8,8,8,6 reps	BWSTT + progressive resistance training 10,8,8,8,6 reps
Tests				
		Week 9		
Cardiorespiratory and functional training	BWSTT + progressive resistance training 8,6,6,6,4 reps	Cardiorespiratory and functional training	BWSTT + progressive resistance training 8,6,6,6,4 reps	BWSTT + progressive resistance training 8,6,6,6,4 reps
Tests				
		Week 10 - Theme week		
BWSTT	BBWSTT + gait training	BWSTT + progressive resistance training 8,6,6,6,4 reps	BWSTT + gait training	BWSTT + Walkathon
Tests				
Compliance rating		Week 11		
Cardiorespiratory and functional training	BWSTT + progressive resistance training 10,8,8,6 reps	Cardiorespiratory and functional training	BWSTT + progressive resistance training 10,8,8,6 reps	BWSTT + progressive resistance training 10,8,8,6 reps
Tests				
		Week 12		
Cardiorespiratory and functional training	BWSTT + progressive resistance training 8,6,6,4 reps	Cardiorespiratory and functional training	BWSTT + progressive resistance training 8,6,6,4 reps	BWSTT + progressive resistance training 8,6,6,4 reps
Tests				
		Week 13		
Final tests at the CRBI, EMG, KinCom and biopsies				

Fig. 10.2 The highly structured schedule of the 12-week CRBI Gait Rehabilitation Programme comprising high-speed body weight support treadmill training (BWSTT) and high-intensity cardiorespiratory training with heavy progressive resistance training for the more affected lower extremity.

no time for discussing intensity, duration, or choice of equipment. To ensure generalization, two theme weeks are interspersed in the 12-week programme in which students practise stair climbing, outdoor walking, riding a tricycle, and various leisure-time activities at the CRBI as well as in their home environment.

Physical training as part of the interdisciplinary day programme

The conclusions from the initial physiotherapeutic examination as well as all test results and ensuing recommendations and goals are written into a report that is shared with the other members of the rehabilitation staff at the weekly staff meeting, where a highly individualized rehabilitation schedule is pieced together and revised whenever necessary.

In the day programme, the bulk of physical training takes place in a well-equipped public fitness centre located at a nearby four-star hotel. Apart from the obvious advantage of gaining access to state-of-the-art equipment, this location also offers the students the possibility of leaving the patient role. Training in a non-clinical setting after a prolonged period of hospitalization greatly boosts students' self-efficacy, once they have overcome their initial reservations with regard to displaying their physical impairments in public. The greatest advantage of using cardiorespiratory and strengthening equipment lies in the possibilities of challenging the students physically to a far greater extent than would be possible without such equipment. Ordinary stair climbing, for example, would never be able to challenge a hemiplegic person as much as training on a Stair Master. The slowness and awkwardness of movement, the tendency to shift function to the less affected side, and the insecure balance of many hemiplegic persons slow down all movement patterns to a degree where neither heart rate nor muscle strength are challenged effectively.

According to the severity of their physical and cognitive difficulties, students are assigned to one to three weekly training sessions at the fitness centre. Each session lasts for 2 hours including the walk to and from the gym and time for changing clothes and showering, leaving the average student an effective training time of 1½ hours. Students train in groups of two to six and are always accompanied by one or two physiotherapists.

Charting training results to ensure continuous progress

The greater the executive disorder the more important it is to organize, time, and chart the routines before and after the actual training, since time spent in the locker room, for example, can seriously encroaches on effective training time. Students are encouraged to time themselves, and examples of distractibility in

dressing, for example, can be used in other domains to exemplify latency in reaction to cognitive tasks (e.g. in the cognitive group at the CRBI or during work trials). Once dressed, the students are required to find their personal folder in the ring binder, take out previous training charts, secure them on a clip board, and add a new training chart (Figure 10.3) on which they write their name and the date. After having copied their weight from the previous training session into the appointed space, they weigh themselves and write their current weight in the space below. By consulting last session's chart, they can fill in the spaces for kilos lifted last time and their highest calorie expenditure ever. Since every training session presupposes an improvement in intensity and output, high, but realistic, goals should be formulated for expected weight lifted and calorie expenditure in the current session, taking into account remaining training time and any comments in the previous session's remarks and plans for the next training session. It goes without saying that almost all students require assistance with the preliminary work with the chart, but entering and comparing data and setting goals are essential to many persons with executive disorders and impaired memory, not only in their rehabilitation process, but also in most other aspects of their lives.

The individual training protocols of the students focus on impacting on whatever elements of strengthening and conditioning are deemed most relevant for optimum restoration of function. By comparing previous training results, such as effort level, lifted weight, and number of repetitions, with the present output, it is the student's responsibility to improve all output within the same 1½-hour time frame. At the end of each training session, all lifted weight in kilos and all expended calories are summed and entered in the spaces below the goals set for the session. With the assistance of a physiotherapist or another student, the students are required to fill in the spaces entitled 'Comments and remarks with regard to today's training session' and 'Plans for next training session'. These two spaces require meta-cognitive processes since reasons for non-fulfilment are usually cognitive rather than physical.

To encourage competition not only with oneself but also with one's peers, high-score charts and graphs of calorie expenditure are drawn up by a physiotherapist or by one of the students at regular intervals.

The charts used for the physical training sessions can be used as templates for any physical rehabilitation session at any level, either acute or post-acute. It is merely necessary to substitute activities and output measures. As mentioned earlier, measures of physical progress and outcome that can be charted include anything measurable from, at the lowest level, the time it takes to walk from bed to bathroom or the number of times sit-to-stand can be performed safely in 1 minute, to, at the highest level, the time it takes to run a certain distance or the number of flights of stairs that can be climbed.

Name		Body weight last time	
Date		Body weight today	
Lifted kilos last time		Highest cal. expenditure ever	
Goal for lifted weight		Goal for calorie expenditure	
Lifted weight today		Calorie expenditure today	

Comments and remarks with regard to today's training session
Plans for next training session

Cardiorespiratory training						
Bicycle	Programme	Distance	HR	Level	Time	**Calories**
Seat:						
Stair Master	Programme	Distance	HR	Level	Time	**Calories**
Tread-mill	Programme	Distance	HR	% / Kph	Time	**Calories**
Skiing machine	Programme	Distance	HR	Level	Time	**Calories**
Arm cycle	Programme	Distance	Arm length	Level	Time	**Calories**
	Bilateral					
Seat:	Uni-lat.					
Rowing machine	Programme	Distance	Watts	Level	Time	**Calories**
Grand total calories						

Progressive resistance training - Arms					
Machine no./name		**Side**	**Kilos**	**Reps**	**Total kilos**
	Pulley high pos	**Right**			
	Pull in/down	**Left**			
	Pulley high pos	**Right**			
	Pull out/down	**Left**			
	Pulley low pos.	**Right**			
	Pull in/up	**Left**			
	Pulley low pos.	**Right**			
	Pull out/up	**Left**			
7	**Chest Press**	**Both**			
		Right			
	Seat:	**Left**			
38	**Low Row**	**Both**			
	Seat:	**Right**			
	Chest:	**Left**			
18	**Lat. Mach.**	**Both**			
3	**Shoulder Press**	**Both**			
		Right			
	Seat:	**Left**			

Progressive resistance training - Legs					
Machine no./name		**Side**	**Kilos**	**Reps**	**Total kilos**
8	**Leg Press**	**Both**			
	Seat:	**Right**			
		Left			
9	**Leg Extension**	**Both**			
	Seat:	**Right**			
	Roller:	**Left**			
10	**Leg Curl**	**Both**			
	Seat:	**Right**			
	Roller:	**Left**			
Grand total kilos					

Fig. 10.3 Excerpt from full training chart.

Goal attainment scaling

In more severe executive disorders, training charts may not ensure the desired progress. In such cases, awareness and motivation can be enhanced by supplementing charts and graphs by goal attainment scaling (GAS). This is a process in which important outcomes are selected in collaboration with individual subjects, and the changes in those outcomes are measured over time. The usual approach for GAS is to use a standard question format for each item and allow the individual to select a preset number of areas of importance (usually three or more). Generally, a list of choices is provided, and the number to be selected is fixed to maintain standardized answers without being too restrictive. To measure the outcomes for each area, a grade scale is used with a minimum of five choices. The units used for the scale may vary depending on the use, but some common examples are from 'much less than expected' (value –2) to 'much more than expected' (value +2), from 'strongly disagree' to 'strongly agree', and from 'very much worse' to 'very much better'.

Summary

Lack of sufficient physical activity has become a universal health threat. Together with the unprecedented availability of food accessible to an ever-increasing number of sedentary people, this inactivity has led to the pandemic of 'diabesity' and other inactivity-related diseases. Insufficient physical activity poses a double threat to people with ABI and/or executive disorders. Not only will a sedentary lifestyle, due to motor sequelae as well as impaired initiative and planning, tend to worsen the physical consequences of the brain injury and thus further reduce mobility and health, but it will also tend to exacerbate the tendency to become increasingly socially isolated. To counter this vicious circle, physiotherapists, and indeed all professionals engaged in rehabilitation and support of brain-injured individuals, should incorporate physical activity into every rehabilitation curriculum or programme. To ensure compliance and carry-over, the activities chosen must be meaningful and accord with the brain-injured person's goals.

Conclusions

Physiotherapists and other groups of professionals dealing with brain-injured individuals may have been motivated to choose their profession by a wish to 'do good', to care for human beings who suffer, in short to put their empathic side to use. Although patients thrive on empathy, therapists should bear in mind that persons with executive disorders are impaired in precisely those domains that are so crucial for initiating and maintaining a regular level of physical activity. Therapeutic empathy does not preclude a high intensity of physical training. At all times, the therapist should remember that he/she possesses the executive faculties that are impaired in the patient and should provide whatever drive, incentive, and structure the patient lacks. Physical exertion and challenge, combined with scrupulous charting of results, continuous progression, and competition with oneself or peers, will often be seen by the patient as more meaningful, rewarding, and fun than submaximal physical activities which, in the short run, only lead to non-discernible improvements but not to fatigue, victory, or improved mood.

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