Evaluation of therapeutic riding (Sweden)/hippotherapy (United States).
A single-subject experimental design study replicated in eleven patients with multiple sclerosis

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The aim of this study was to investigate whether therapeutic riding (TR, Sweden)/hippotherapy (HT, United States) may affect balance, gait, spasticity, functional strength, coordination, pain, self-rated level of muscle tension (SRLMT), activities of daily living (ADL), and health-related quality of life. Eleven patients with multiple sclerosis (MS) were studied in a single-subject experimental design (SSED) study, type A-B-A. The intervention comprised ten weekly TR/HT sessions of 30 minutes each. The subjects were measured a maximum of 13 times. Physical tests were: the Berg balance scale, walking a figure of eight, the timed up and go test, 10 m walking, the modified Ashworth scale, the Index of Muscle Function, the Birgitta Lindmark motor assessment, part B, and individual measurements. Self-rated measures were: the Visual Analog Scale for pain, a scale for SRLMT, the Patient-Specific Functional Scale for ADL, and the SF-36. Data were analyzed visually, semi-statistically and considering clinical significance. Results showed improvement for ten subjects in one or more of the variables, particularly balance, and some improvements were also seen in pain, muscle tension, and ADL. Changes in SF-36 were mostly positive, with an improvement in Role-Emotional seen in eight patients. Conclusively, balance and Role-Emotional were the variables most often improved, but TR/HT appeared to benefit the subjects differently.

Introduction

Multiple sclerosis (MS) is a common cause of functional disorder in persons of able-bodied age. The female to male ratio is about 2:1. The disease is commonly divided into a relapsing-remitting form and a progressive form (primary or secondary; Jönsson and Ravnborg, 1998).
Treatment and help to overcome disability and handicap are the mainstay in the management of MS patients (Jønsson and Ravnborg, 1998; Kraft, 1999). Multiple sclerosis presents us with a special challenge, partly because of the multiplicity of symptoms and functions that are affected, and partly because of the unpredictable, progressive course of the disease. Rehabilitation in MS must consequently be individually adapted (Jønsson and Ravnborg, 1998; Ko Ko, 1999).

The physiotherapeutic goals have often been to reduce the symptoms, and practice functional movements and strategies for compensation of lost function, thus aiming to restore the highest possible level of independence. Physiotherapy (PT) for MS patients has been evaluated in some studies (Fuller, Dawson, and Wiles, 1996; Jones, Lewis, Harrison, and Wiles, 1996; Lord, Wade, and Halligan, 1998), which show that PT provides a higher level of function and that different physiotherapeutic approaches have been used with equivalent results (Lord, Wade, and Halligan, 1998). It is important that PT should involve actions aimed at, and evaluation of, all components of the World Health Organization (WHO)’s International Classification of Functioning, Disability and Health (ICF), namely, body functions and structures, activities, and participation (World Health Organization, 2001). Therapeutic riding (TR) has been used for many years to cover a variety of equine activities in which people with various disabilities participate. The term has caused some confusion since disparate definitions and interpretations of TR exist. MacKay-Lyons, Conway, and Roberts (1988) distinguish between sport and TR, arguing that in the former, the rider affects the horse and in the latter, the horse affects the rider. Biery (1985) has defined TR as a program in which the primary objective is rehabilitation rather than pure recreation or the teaching of riding skills. The adjacent term “hippotherapy” (HT) is an intervention of PT through horseback riding based on neurophysiological principles (Strauss, 1991), in which the subject is described as passive. This is in agreement with the definitions from the North American Riding for the Handicapped Association. A precise description of hippotherapy is still evolving according to Heine (1997).

On the horse’s back, the rider is placed in a position that inhibits extension spasticity of the legs and applies a long-lasting stretching of the hip adductors. These mechanisms can be useful in reducing abnormally high muscle tone (Bertoti, 1988; MacKay-Lyons, Conway, and Roberts, 1988). Balance can be improved if neuromuscular and vestibular mechanisms are affected. As the horse walks, its center of gravity is displaced three-dimensionally with a rhythmical movement very similar to that of the human pelvis during gait. The horse is therefore used as a therapeutic medium in both HT and TR. With the active riding component, the learning of a new skill is added. This may add a positive motivational factor for the rider, apart from the therapeutic gain. Therapeutic riding can raise the patient’s self-confidence and self-efficacy (Bertoti, 1988; MacKay-Lyons, Conway, and Roberts, 1988; MacKinnon et al, 1995).

In Sweden, TR is widely used both in disabled children and in adults. At the Örebro University Hospital, Örebro, Sweden, physiotherapists (PTs) have since 1992 provided TR for adults with neurological disorders. A physician’s referral is required and TR is on a par with other PT interventions and consequently financed by the Public Health system. In contrast, the Medical Therapy Model in the United States (US) only incorporates this intervention if it is defined as HT. TR, as described in this paper, may be considered on a par with HT in the US. In this study, the intervention being studied is named TR, which is the term used further on in this paper.

Scientific evaluation of TR is scarce (Pauw, 2000). MacKinnon et al (1995) and Pauw (2000) reviewing the literature on TR found several descriptive studies that contained observations and subjective statements on the topic. Only a few studies have, however, used statistical methods for analysis of TR effects on people with neurological impairments. A statistically significant improvement after TR was shown by postural changes in eleven children with spastic cerebral palsy (CP; Bertoti, 1988). With
regard to patients with MS, the literature search only provided one outcome study using TR (MacKay-Lyons, Conway, and Roberts, 1988). They report a positive influence on walking velocity and psychological wellbeing in the nine subjects completing the 9-week trial with intervention conducted twice weekly and evaluated by pre- and posttesting. There was no change in neurological and functional assessment and postural sway.

There is a great need for more evaluation of the physiotherapeutic effects of TR. The descriptive articles have helped identify variables that need to be objectively examined (MacKinnon et al, 1995). Proposed physical outcome variables are balance, muscle strength, joint range of motion, coordination, and muscle tone. Proposed psychosocial outcomes are self-confidence, self-concept, self-esteem, concentration, attention span, and spatial awareness. Besides, pain occurs in over 50% of MS patients, with considerable impact on health (Polman, Thompson, Murray, and McDonald, 2001), which also makes these variables important to evaluate.

The aim of this study was to investigate how individual patients with MS respond to TR. The variables of specific interest were: balance, gait, spasticity, functional strength, coordination, pain, self-rated level of muscle tension, activities of daily living, and health-related quality of life.

Methods

Design

A single-subject experimental design (SSED), type A-B-A, was used, which allows individual responses to be followed (Franklin, Allison, and Gorman, 1997; Ottenbacher, 1986). SSED was considered to be appropriate (Ko Ko, 1999) because heterogeneity of the MS population can be confounding in group studies (Riddoch and Lennon, 1994) and also, because there are few scientific reports on TR and SSED can be used for exploring a new science field (Ottenbacher, 1986). With SSED the treatment can be administered like in the clinic (Domholdt, 2000). The study consisted of three phases, namely, baseline phase A1 of 3–5 weeks (the pretreatment period), phase B of 10–11 weeks’ intervention, and finally, a second baseline phase A2, of 3–4 weeks. The second baseline phase was included to investigate whether the changes, if any, would be maintained. Total time of the study for each patient was 16–18 weeks (Figure 1).

Subjects

Subjects were recruited among patients who had been referred for TR. The criterion for inclusion was MS diagnosed by a neurologist. Exclusion criteria were an ongoing relapse, participation in TR at any time during the 6 months period before the study start, and a body weight of >85 kg. The weight restriction was given due to regulations at the riding school. The participants were not to begin any PT or other exercising 4 weeks before and during the study period. They were, however, permitted to continue with home exercise programs. The subjects were asked not to change their medication during the study period. If any such alternations were made, subjects were asked to record them.

Originally, the 2:1 female–male ratio was aimed for when recruiting participants, but it turned out to be more difficult to recruit men than women, because of the weight restrictions. Thirteen participants who met the criteria, two men and eleven women were included. They were given verbal and written information about the study and consented to participate. One woman withdrew due to aggravation of already existing hip pain (Subject 3) and one woman withdrew for personal reasons (Subject 10). Eleven subjects completed the study, two men and nine women. The mean age was 47.9 years (standard deviation \[ SD \] 8.4, range 35–61 years). Table 1 presents characteristics of the participants, such as years since diagnosis (mean 10, median 7 years), expanded disability status scale (EDSS) score (mean 5.0, median 6.0; Kurtzke, 1983), type of MS, social status, previous riding periods, medication, and walking aids indoors and outdoors. Information on medication for pain, spasticity, and mood/depression is based on the medical records.

Intervention

The intervention comprised ten weekly TR sessions, each lasting 30 minutes. Each subject rode at the same time of day throughout the
intervention period. The riding took place indoors and all except one rode in pairs. Two PTs were in charge of the treatment assisted by one riding instructor. The PTs established the treatment plan to facilitate treatment goals and was responsible for choosing the appropriate exercises also concerning intensity and sitting position (Heine, 1997). The PTs cooperated with the riding instructor regarding choice of appropriate horse and equipment. As in all PT intervention the PTs analyzed and adjusted to provide the most effective treatment for each patient along the intervention period. The riding instructor was in charge of the riding safety and the riding instructions. None of them took any part in the measurements. One of these PTs (YN) kept an individual record for each subject for every riding session in order to adjust treatment. This record documented status, changes, and improvements in balance-demanding tasks, endurance, and riding skill (Heine, 1997). During the period of data collection, no communication of the data or regarding the riding took place between the PTs involved. Where needed, assistance was given by leading the horse and/or walking beside the subject. The limit of completed intervention was set to eight or more TR sessions.

The TR was individually tailored to the subjects’ physical needs and ability to ride. Each riding session began and ended with a few minutes’ physical exercise with the aim to provide a better sitting position and to enhance the balance component on horseback. Exercises contained trunk rotation components, for example reaching for the horse’s ears or tail with one hand, reaching for the opposite knee or diagonally, towards the ceiling. Other exercises involved maintaining balance while holding both arms in the air (abducted or flexed towards the ceiling) or riding without visual input, as well as lying prone with the arms around the horse’s neck while the horse was either moving or standing still, and then rising again.

Exercises that combined selected training components from a physiotherapeutic perspective with enhancing riding skills were then carried out. They included weaving through cones, changing the reins through centerline, and riding diagonals and circles. Postural adjustment is required whenever a horse moves or when changes in speed or direction take place. Riding over poles further enhanced balance components. Mostly, the subjects rode at a walking pace but many tried a few laps of trot. One subject had been riding before the onset

Figure 1. Illustration of the design with the three phases (A1, B, and A2). The measurement sessions are indicated for each instrument used.

<table>
<thead>
<tr>
<th>Phase A1</th>
<th>Phase B</th>
<th>Phase A2</th>
</tr>
</thead>
<tbody>
<tr>
<td>x x x x</td>
<td>x x x x</td>
<td>x x x x</td>
</tr>
<tr>
<td>* * * *</td>
<td>* * * *</td>
<td>* * * *</td>
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<tr>
<td>** ** **</td>
<td>** ** **</td>
<td>** ** **</td>
</tr>
</tbody>
</table>

x = Measurement sessions 1-13

Instruments used:
* = Berg Balance Scale, Timed up and go test, 10 m walking test, Modified Ashworth Scale, Index of Muscle Function, Birgitta Lindmark motor assessment and Individual measurements.
** = Walking a figure of eight.
□ = Patient-Specific Functional Scale, SF-36.
# = Self-rated level of muscle tension (SRLMT) and Visual Analog Scale (VAS) of pain (daily).
Table 1. Characteristics of the subjects, such as years since diagnosis, expanded disability status scale (EDSS) score, type of multiple sclerosis (MS), social status, previous riding periods, medication, and walking aids indoors and outdoors. Medication for pain, spasticity, and mood/depression is listed as given in the medical records.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Years since diagnosis</th>
<th>EDSS</th>
<th>Type of MS</th>
<th>Social status</th>
<th>Pension/work</th>
<th>Previous riding periods</th>
<th>Medication</th>
<th>Walking aids indoors</th>
<th>Walking aids outdoors</th>
<th>Aids indoors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>4.0</td>
<td>Rel-remitt</td>
<td>Lives alone</td>
<td>Retired</td>
<td>Several</td>
<td>None</td>
<td>None</td>
<td>1 crutch</td>
<td>1 cane</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>6.0</td>
<td>SPMS</td>
<td>Lives with spouse</td>
<td>Retired</td>
<td>Two</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>1 cane</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>6.5</td>
<td>SPMS</td>
<td>Lives with spouse</td>
<td>Retired</td>
<td>Two</td>
<td>Baclofen, Imigran Baclofen</td>
<td>None</td>
<td>Electric wheelchair</td>
<td>None, rarely a wheelchair</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>6.5</td>
<td>SPMS</td>
<td>Lives with spouse</td>
<td>50% work/50% retired</td>
<td>Several</td>
<td>None</td>
<td>None</td>
<td>Rarely a wheelchair</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>2.5</td>
<td>SPMS</td>
<td>Lives with family</td>
<td>75% sick leave</td>
<td>One</td>
<td>Cipramil</td>
<td>None</td>
<td>None</td>
<td>Rarely a wheelchair</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>1.5</td>
<td>Rel-remitt</td>
<td>Lives with family</td>
<td>Sick leave/50% work</td>
<td>One</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Rarely a wheelchair</td>
</tr>
<tr>
<td>8</td>
<td>0.5</td>
<td>6.0</td>
<td>Rel-remitt</td>
<td>Lives with family</td>
<td>50% work/50% sick leave</td>
<td>Advanced rider before MS onset</td>
<td>Beta-Interferon, Sobril, Neurontin, Tryptizol</td>
<td>None</td>
<td>None</td>
<td>Rarely a wheelchair</td>
</tr>
<tr>
<td>9</td>
<td>15</td>
<td>5.5</td>
<td>SPMS</td>
<td>Lives with spouse</td>
<td>Retired</td>
<td>One</td>
<td>None</td>
<td>None</td>
<td>Rolling walker, wheelchair</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>5</td>
<td>6.0</td>
<td>PPMS</td>
<td>Lives alone</td>
<td>Retired</td>
<td>One</td>
<td>None</td>
<td>None</td>
<td>Cane/rolling walker, wheelchair</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>9</td>
<td>3.0</td>
<td>Rel-remitt</td>
<td>Lives with spouse</td>
<td>50% work/25% sick leave</td>
<td>One</td>
<td>Baclofen, Beta-interferon</td>
<td>Sometimes a crutch</td>
<td>Sometimes a crutch</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>29</td>
<td>7.5</td>
<td>SPMS</td>
<td>Lives alone</td>
<td>75% retired/25% work</td>
<td>Several</td>
<td>Baclofen</td>
<td>Unable to walk</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
of MS and was therefore able to do more advanced riding exercises.

**Measurements**

Instruments were chosen to cover areas where patients with MS supposedly experience problems and where TR was proposed to have an effect (MacKinnon et al, 1995) and to cover the ICF components (World Health Organization, 2001). In a few cases, instruments could be chosen that had previously been tested for validity in an MS population.

**Physical tests**

**Balance:** was measured with the Berg balance scale (BBS; Berg, Wood-Dauphinee, and Williams, 1995; Berg, Wood-Dauphinee, Williams, and Maki, 1992), walking a figure of eight (Frändin, Sonn, Svantesson, and Grimby, 1995; Johansson and Jarnlo, 1991), and the timed up and go (TUG) test (Podsiadlo and Richardson, 1991). The BBS consists of 14 items, scored 0–4, that require subjects to maintain positions of varying difficulty and perform specific tasks. Several items include time and distance requirements. Walking a figure of eight is a dynamic balance test of walking without aids. The figure consists of two sets of two circles, the inner circle with a diameter of 1.50 m, the outer with a diameter of 1.65 m. The ability to walk twice through the figure of eight in the space between the circles is tested and the number of oversteps or touches are recorded. The TUG test is used to measure physical mobility and balance. It measures the time taken by the subject to stand up from an ordinary armchair, walk 3 m, turn, walk back to the chair, and sit down again. Walking aids are allowed and their use recorded.

For individual measurements: the scores of separate items in the BBS were inspected to detect specific changes. As a complement, individual measurements were performed of subjects who came close to the ceiling effect on the BBS. This included timed activities from the BBS, such as the actual time the subject achieved in tandem position or in standing on one leg.

One subject who was unable to walk and only scored 4 points on the BBS was mainly tested for balance in sitting. In this regard, the following individual measurements were chosen: 1) time sitting unsupported on a balance pillow; 2) distance (cm) from the floor when leaning forward to maximum without falling and still being able to rise unsupported; and 3) active movements of the neck in degrees for flexion, extension, rotation, and lateral flexion, while unsupported sitting is maintained. As a test of standing balance, the time the subject was able to stand unsupported was measured.

**Gait:** was measured with the 10 m walking test (Wade et al, 1987) at maximum speed. The time and the number of strides were registered and the velocity calculated in m/s. The best out of three attempts was used. Use of walking aids was recorded. The 10 m walking test has been proposed elsewhere to be a useful tool in measuring clinical outcome for MS patients (Rudick et al, 1997).

**Spasticity:** was measured with the modified Ashworth scale (MAS; Bohannon and Smith, 1987). Palmar flexors of the hand, elbow flexors and extensors, knee extensors and flexors, and plantar flexors of the foot were scored 0–5, all in a sitting position. Individual muscles separately, as well as sums for each extremity, sums for body halves, and the total sums were analyzed (Lechner et al, 2003, Nuyens et al, 1994).

**Functional strength:** was measured through two items from the Index of Muscle Function (IMF; Ekdahl, Englund, and Stenström, 1999). The items chosen were 1) the ability to bend the knees to a maximum of 90 degrees and rising while standing with the back against a wall; and 2) stepping up onto a step (height 17 cm) without hand support, items rated 0–2.

**Coordination:** was measured with the Birgitta Lindmark motor assessment (BLMA), part B, testing rapid movement changes (Lindmark and Hamrin, 1988). The items included were flexion/extension of the elbow, pronation/supination of the arm, flexion/extension of the knee, and flexion/extension of the ankle, items rated 0–3. Individual items separately, as well as sums for each extremity, sums for body halves, and the total sums were analyzed.
Self-rated measures

Pain: was rated daily throughout the study period, preferably in the afternoon, with a 100 mm Visual Analog Scale (VAS; Carlsson, 1983) marked “no pain” on the left and “unbearable pain” on the right. The charts were handed out and collected weekly by the examiner.

Self-Rated Level of Muscle Tension: (SRLMT) was assessed on a study-specific 7-point scale by subjects rating their own experience of muscle tension compared with how it usually felt. “No change in muscle tension” was in the middle, and “much less tense” was at one end of the scale while “much more tense” was at the other end. Every day throughout the study period, subjects filled out a separate chart for the arms and legs. Scores were allocated according to Table 2.

Activities of Daily Living: (ADL) was assessed with the Patient-Specific Functional Scale (PSFS; Chatman et al, 1997; Westaway, Stratford, and Binkley, 1998). The subjects were asked to choose one or two activities with which they were experiencing difficulties in their daily life, then grading the difficulty from 0 = unable to perform the activity to 10 = able to perform the activity without problem.

Health-Related Quality of Life: (HRQOL) was assessed with the short form 36 (SF-36) health survey (acute version), which has been translated into Swedish and tested for validity and reliability (Persson et al, 1998; Sullivan and Karlsson, 1998). Previous studies have shown that the SF-36 captures disease effects of MS (Nortvedt, Riise, Myhr, and Nyland, 1999). All items were coded, summed, and transformed into a scale of 0-100 (0 = worst health, 100 = optimal health), according to the standard procedure. Scores in eight different health dimensions present the result. The dimensions are Physical Functioning (PF), Role-Physical (RP), Bodily Pain (BP), General Health (GH), Vitality (VT), Social Functioning (SF), Role-Emotional (RE), and Mental Health (MH).

Diary: The participants were asked to fill in a chart daily with a report on anything that they thought affected their physical and mental status. This could for example include tiring activities, changes in medication, social activities, infections, and mood.

Procedure

The participants were measured weekly during phase A1 (four times), four to five times during phase B, and weekly during phase A2 (three to four times), in total, a maximum of 13 times (see Figure 1). The measurements in both A phases took place in a PT department but in phase B, measurements were done at the riding school just before a TR session. To obtain an equal situation in all phases and to demand changes to remain for at least 1 week, all measurements were performed prior to the TR.

Each measurement session lasted 15-45 minutes and took place at roughly the same time of day. The assessments were made in the following order: 1) the MAS; 2) the BLMA; 3) the BBS; 4)

<table>
<thead>
<tr>
<th>Table 2. Transformation of the verbal expressions in the chart to scores used for self-rated level of muscle tension (SRLMT).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expressions in the chart</strong></td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>Much less tense in the muscles than usual</td>
</tr>
<tr>
<td>Moderately less tense in the muscles than usual</td>
</tr>
<tr>
<td>Slightly less tense in the muscles than usual</td>
</tr>
<tr>
<td>No change in muscle tension</td>
</tr>
<tr>
<td>Slightly more tense in the muscles than usual</td>
</tr>
<tr>
<td>Moderately more tense in the muscles than usual</td>
</tr>
<tr>
<td>Much more tense in the muscles than usual</td>
</tr>
</tbody>
</table>

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individual measurements; 5) the TUG test; 6) the 10 m walking test; and 7) the IMF. Walking a figure of eight was tested only in the two A phases, since the figure was not available at the riding school. At every session, the charts for pain and SRLMT and the diary were collected and new ones handed out. At the first and the last measurement session, the subjects were also asked to fill in the SF-36 and PSFS, to obtain a pre- and a postscore. Background data (Table 1) were collected both by asking the patient and by consulting the medical records.

One PT (AF or HP) performed all the measurements in each subject throughout the study. To avoid bias, these two PTs were not involved in the riding sessions.

Data analysis

The analysis was performed through visual inspection of graphs, using a semi-statistical approach and considering clinical significance. The changes occurring had to be related to the intervention phase. Also, the diary and the riding record were used to seek confirmation of, or disagreement with, the interpretation of the collected data, but they never determined the evaluation.

The visual analysis of graphs included level (median and mean), variability, trend and slope within and between phases (Franklin, Allison, and Gorman, 1997). According to Ottenbacher (1986: 138), “treatment effects should be obvious from visual inspection of the data,” an approach followed in the present study. The trend line was calculated by least-square regression as representing the best linear fit (Franklin, Allison, and Gorman, 1997; Ottenbacher, 1986).

Semi-statistical analysis was performed with the two SD band method. Horizontal lines are drawn in the graph at the band of two SDs from the mean level at baseline. If at least two successive observations during the intervention phase fall outside this band, a statistically significant change has occurred across phases (Domholdt, 2000; Ottenbacher, 1986).

Clinical significance represents important change occurring in the subject’s performance (Franklin, Allison, and Gorman, 1997). The judgments of clinical significance were referred to responsiveness estimates reported in Physical Rehabilitation Outcome Measures (Finch, Brooks, Stratford and Mayo, 2002) for the BBS total score (six points’ improvement below 40, three points in the forties and two points above 50), for gait velocity (>0.17 m/s) and for PSFS (2.5 score points).

For the other instruments the limit of 15% as a clinically significant change was used (Philadelphia Panel, 2001). For the TUG test, the walking a figure of eight and the timed individual measurements the change of 15% was used as change from baseline values. The 15% change for the other measurements were within total range for the scale: for the individual BBS items (scored 0–4) 0.75 score point; MAS sum score lower extremities (0–30) 4.5; VAS 15; SRLMT 1.0; and the SF-36 at least 15.

Microsoft Excel was used for arranging the measurements individually (a total of roughly 13,000 data; Carr and Burkholder, 1998). Physical tests with five or fewer measurement sessions were excluded from the interpretation. The results for each subject were discussed at separate case meetings. Decisions of + (positive change, or improvement, between phases), − (negative change, or deterioration, between phases), and 0 (no change between phases) were made according to the methods described for every measurement. For + on the variable balance, improvement in at least two measurements was claimed. For the daily recordings (VAS and SRLMT), less variability during phase B; decelerating trend in phase B or short-term decreases following most of the TR sessions was also classified as change. Both PSFS and SF-36 were analyzed from the obtained pre- and postscore.

Ethics

The study protocol was approved by the Ethical Committee at Örebro University Hospital, Örebro, Sweden.

Results

Results on a case-by-case basis

Subject 1 (S1) had weakness, slightly increased muscle tone in the legs, and problems
Table 3. Results in health-related quality of life (HRQOL) measured by the short form 36 (SF-36) health survey presenting the pre- and postscores on each dimension for the eleven subjects.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Subject No</th>
<th>Physical Functioning Pre</th>
<th>Post</th>
<th>Role-Physical Pre</th>
<th>Post</th>
<th>Bodily Pain Pre</th>
<th>Post</th>
<th>General Health Pre</th>
<th>Post</th>
<th>Vitality Pre</th>
<th>Post</th>
<th>Social Functioning Pre</th>
<th>Post</th>
<th>Role-Emotional Pre</th>
<th>Post</th>
<th>Mental Health Pre</th>
<th>Post</th>
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<tr>
<td></td>
<td>1</td>
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<td>56</td>
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</table>

A positive score change of ≥15.
A negative score change of ≥15.
Score change <15.
**Table 4.** Balance results presented as means and standard deviations (SDs) of phases A1, B and A2 for the eleven subjects in the Berg balance scale (BBS), individual measurements, the timed up and go (TUG) test, and walking a figure of eight.

<table>
<thead>
<tr>
<th>Subject No</th>
<th>BBS total score</th>
<th>Individual measurement</th>
<th>Timed up and go (sec)</th>
<th>Figure of eight (number)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>Turning two laps in standing (sec)</td>
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<tr>
<td>2</td>
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<td></td>
<td></td>
<td>Turning two laps in standing (sec)</td>
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<td></td>
<td>BBS item 7</td>
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<td>BBS item 11</td>
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<td></td>
<td>BBS item 10</td>
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<tr>
<td>Time for figure of eight (sec)</td>
<td>Time in tandem position (sec)</td>
<td>BBS item 7</td>
<td>Alternating placing of feet on step (sec)</td>
<td>Distance to floor (cm)</td>
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<td>-------------------------------</td>
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</tr>
<tr>
<td>7 56.0 56.0 56.0 22.3 *26.2</td>
<td>9 50.7 52.8 52.3 12.5 38.9 36.0 *9.9 10.2</td>
<td>11 48.8 52.8 53.3 6.2 31.1 49.7 *2.5 4.0</td>
<td>12 48.0 *50.8 *53.7 21.4 15.3 13.6 1.0 1.8 4.0</td>
<td>13 4.0 4.0 4.0 45.5 *22.8 *17.7 3.5 *929 *1119</td>
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<tr>
<td>(0.0) (0.0) (0.0) (2.2)</td>
<td>(0.9) (0.8) (0.9) (10.2)</td>
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<td>(0.7) (1.9) (0.9) (2.8)</td>
<td>(0.0) (0.0) (0.0) (2.2)</td>
</tr>
<tr>
<td>8 54.0 55.7 56.0 (1.6) (0.5) (0.0) No individual measure was used</td>
<td>8 56.0 (1.6) (0.0) (0.0) No individual measure was used</td>
<td>8 16.3 14.1 *7.0 # # # #</td>
<td>8 1.0 (0.0) (0.0) (1.3) (0.0)</td>
<td>8 3.5 (3.6) (1.2)</td>
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<td>(0.0) (0.0) (0.0) (1.2)</td>
<td>(0.6) (0.0) (0.0)</td>
<td>(2.8) (2.9) (0.0)</td>
<td>(0.0) (0.0) (0.0) (0.0)</td>
<td>(1.0) (46.9) (11.4)</td>
</tr>
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<td>3.5 *92.9 *111.9 # # # # # # # # # # + +</td>
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</table>

* = statistically significant change compared to phase A1 according to the two standard deviation (SD) band method. The shadow indicates clinically significant changes from phase A1 following criteria presented in the data analysis section. CSC = subjects making both clinical and statistical significant changes in at last two balance measures; # # # = subject could not perform the test; BBS = Berg balance scale; BBS item 6: standing with eyes closed; BBS item 7: standing with feet placed close together; BBS item 10: standing while looking back; BBS item 11: turning 360 degrees.
with dynamic balance requiring a wide base of support when walking. This subject was close to the ceiling on several of the measurements during phase A1. According to the riding record, this subject was able to sit more symmetrically on the horse and had improved stability during exercises. A negative change was seen in four and a positive in two SF-36 dimensions (Table 3). Result summary for S1: no changes except for HRQOL showing diverging changes.

Subject 2 (S2) had weakness in both arms and legs, was troubled by fatigue, and problems with dynamic balance requiring a wide base of support when walking. This subject was at, or close to, the ceiling on several of the measurements during phase A1. The riding record expressed improvement in balance, stability, and symmetry. A positive change was seen in two SF-36 dimensions (Table 3). Result summary for S2: HRQOL showed positive change.

Subject 4 (S4) had weakness and moderately increased muscle tone in the legs, trunk, and left hand/arm. This subject had areas of sensory loss in the legs and problems with fatigue. Balance was to some extent improving already from A1 to B regarding the slightly better level and less variable results for the individual measurements and TUG. The total BBS score and one individual measurement improved significant, clinically and statistically to A2 (Table 4). A negative change was seen in five SF-36 dimensions (Table 3). According to the riding record S5 improved balance and stability despite problems with tiredness and back pain experienced during the TR sessions. Result summary for S5: a positive change was recorded in balance and a negative change was seen in HRQOL.

Subject 6 (S6) had fatigue and balance problems in standing and walking, sensory loss in the legs, and numbness in one hand. This subject had discrete weakness in the right side and the walking distances had been drastically decreased. The improved level in the total BBS score and in the walking a figure of eight (Table 4) were mainly made during phase A1 and apparently not related to the intervention. Though, one individual measurement of balance showed clinical and statistical significant change and the other one stabilized on a higher, maximum level in phase B (Figure 4) which indicated improved balance from phase A1 to B, also maintained in A2. A positive change was seen in four SF-36 dimensions (Table 3). Also, PSFS score was higher after the intervention (Table 5). In the other measurements, S6 scored maximum in phase A1 and no changes could be expected. According to the riding record, S6’s posture improved and this subject could successively manage more advanced riding exercises. Result summary for S6: a positive change was seen in balance, ADL and HRQOL.

Subject 7 (S7) experienced discrete weakness in the arms and legs, fatigue after walking distances exceeding 1–2 km, occasional dizziness, and deep pain in the back and legs. In several of the measurements, S7 scored at the ceiling in phase A1 and no changes could be expected. Subject 7 had no baseline measures of VAS and SRLMT (Table 5), but during phase B the self-ratings of pain decreased (Figure 5) and muscle tension showed decreased variability, which were interpreted as positive changes. The riding record stated that S7 had good balance from start of the intervention but an improvement was seen in riding skills. Positive change was seen in two SF-36 dimensions (Table 3). Result summary for S7: a positive change was seen in pain, SRLMT and HRQOL.

Subject 8 (S8) suffered from extreme fatigue when standing and walking, sensory loss in the
Figure 2. Subject 4 improved between phase A1 and B in the modified Ashworth scale (0–5). Sum score for spasticity in the legs, 0–30. Mean lines (solid) and two standard deviation (SD) band (dashed) are indicated.
Table 5. Results for the eleven subjects, presented as means and standard deviations (SDs) of phases A1, B and A2 in gait velocity, spasticity, pain, self-rated level of muscle tension (SRLMT), and pre- and post-scores on ADL.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Gait velocity (m/s)</th>
<th>Spasticity (sum score for lower extremity)</th>
<th>Pain (VAS 0–100)</th>
<th>Self-rated level of muscle tension (SRLMT)</th>
<th>ADL (PSFS 0–10)</th>
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</table>

* = statistically significant change compared to phase A1 according to the two standard deviation (SD) band method. The shadow indicates clinically significant changes from phase A1 following criteria presented in the data analysis section. ####### = subject could not perform the test; VAS = Visual Analog Scale; ADL = activities of daily living; PSFS = Patient – Specific Functional Scale.
Figure 3. Subject 5 improved between the phases in the Berg balance scale. Sum score, 0–56. Mean lines (solid) and two standard deviation (SD) band (dashed) are indicated.
Subject 6 improved from phase A1 to B in item 10 (standing while looking back) of the Berg balance scale. The two standard deviation (SD) band (dashed) is indicated.
Figure 5. Subject 7 improved during phase B in the daily self-ratings of pain using the Visual Analog Scale. The trend line in phase B is indicated. The dates in phase B represent the therapeutic riding sessions.
legs and lower trunk, and neuralgic pain in the legs. The 10 m walking test showed increased gait velocity (Table 5) between the phases. Also, S8 needed two crutches in phase A1 but no aids in A2, and managed to make all three attempts at the test in phase A2, compared with just one in A1. The total BBS score reaching ceiling effect during phase B together with TUG improving from phase A1 to A2 was interpreted as positive changes in balance. Subject 8 had a stable level of SRLMT in phase A1 and improved by 1 whole point in each phase, which was clinically and statistically significant (Figure 6). The improved pain level (Table 5) was mainly made during phase A1 and apparently not related to the intervention. Since S8 had been riding prior to MS, the complexity of riding exercises was rather advanced. Two positive and one negative score changes were seen in SF-36 (Table 3). Result summary for S8: a positive change was seen in balance, gait, SRLMT but HRQOL showed diverging changes.

Subject 9 (S9) had weakness in the arms and legs, problems with fatigue and dizziness, and reduced walking distance to about 100 m. Several of the measurements displayed large variability, making interpretation difficult. However, self-rated pain was judged as improved since the trend decelerated and the variability decreased during phase B. Short-term decreases after most of the TR sessions were also seen, especially when the variability was larger (Figure 7). The subject's notes in the diary stating that the back pain was decreasing from the riding validated this interpretation. The positive change of level of two points from phase A1 to B seen in the total BBS score was clinically significant (Table 4). Also, one individual measurement of balance showed clinical and statistical significant change and the other one a clinically significant higher level in phase B (Table 4). These together indicate improved balance from phase A1 to B also maintained in A2. The riding record presents a tendency towards improved symmetry and posture, and more confidence in riding. Three positive and three negative score changes were seen in SF-36 (Table 3). Result summary for S9: a positive change was seen in balance and pain, but HRQOL showed diverging changes.

Subject 11 (S11) had weakness in the arms and legs, fatigue, and problems with dynamic balance. Subject 11 showed both statistically and clinically significant improvements between the phases in the two individual measurements of balance (Table 4). Though, the improved level in the total BBS score was mainly made during phase A1 and apparently not related to the intervention. There was an improvement in the PSFS (Table 5) as well as in SF-36, with a positive change in four dimensions (Table 3). According to the riding record, an improvement in balance and endurance was noted. Result summary for S11: a positive change was seen in balance, ADL and HRQOL.

Subject 12 (S12) had weakness in the legs, fatigue and problems with dynamic balance. This subject improved significant, statistically and clinically between phases in the total BBS score as well as in some of the items (Table 4). Improved balance was expressed in the riding record. The PSFS scores were higher after the intervention (Table 5). There was a positive change in two SF-36 dimensions and a negative change in one (Table 3). Result summary for S12: a positive change was seen in balance and ADL, but HRQOL showed diverging changes.

Subject 13 (S13) had substantial weakness in both arms and legs, was unable to walk, and had problems with fatigue. Subject 13 showed substantial improvement between phases in sitting balance with a sharp and significant change of level in the individual measurements (Table 4, Figure 8). The pain level decreased slightly from phase A1 to phase B and short-term decreases were seen in phase B after most of the TR sessions, which was considered of clinical significance. There was improvement in PSFS scores (Table 5) and a positive change in five of the SF-36 dimensions (Table 3). The riding record reports improvement in trunk stability, posture, and endurance. Result summary for S13: a positive change was seen in balance, pain, ADL and HRQOL.

Result summary

A summary of the results in the physical tests and the self-rated measures for the eleven subjects is shown in Table 6. The improvements seen with the approach claiming both clinical and statistical significant changes (two SD band method) are specially indicated. Since this
Figure 6. Subject 8 improved between the phases in the daily self-ratings of level of muscle tension in the legs. The dates in phase B represent the therapeutic riding sessions.
Figure 7. Subject 9 improved in the daily self-ratings of pain using the Visual Analog Scale. The trend line in phase B is indicated. The dates in phase B represent the therapeutic riding sessions.
Figure 8. Subject 13 improved between the phases in an individual measurement of sitting balance (distance from the floor when leaning forward without falling and still being able to rise unsupported). Mean lines (solid) and two standard deviation (SD) band (dashed) are indicated.
approach mainly is based on changes of level it
does not cover the other SSED interpretations.
When regarding this more qualitative analysis
detailed presented in the case-by-case section,
some more improvements were seen (Table 6).

Balance was the physical variable most often
showing improvement. Improvement was seen in
four subjects from phase A1 to B and in five sub-
jects from phase A1 to A2 if both clinical and
statistical significant changes were claimed
(Tables 4 and 6). Adding the more qualitative
aspect of interpretation, balance improvement
was seen in eight subjects.

In the other physical tests few improvements
were seen (Tables 5 and 6). If both clinical and
statistical significant changes were claimed, only
gait velocity improved; S8 from phase A1 to A2
(Table 5). Spasticity improved in one subject
(S4) when adding the more qualitative aspect
of interpretation. No subject improved in func-
tional strength or coordination. No deterio-
roration was seen among the physical tests. The
only reversal was the lower level of spasticity
not being maintained in S4 when the inter-
vention was withdrawn.

In the self-rated measures improvement was
seen in one subject (S8) if both clinical and stat-
istical significant changes were claimed; from
phase A1 to B in SRLMT with further improve-
ment from phase B to A2 (Tables 5 and 6). Add-
ing the more qualitative aspect of interpretation,
 improvement was also seen in pain and SRLMT.
Three subjects who initially reported pain
reported some pain reduction related to the
intervention. Three subjects scored an improve-
ment in the SRLMT. Four subjects rated an
improvement in ADL score (Tables 5 and 6). In
pain, SRLMT or ADL, no deterioration
was seen.

In HRQOL 28 positive and 16 negative
changes were recorded (Table 3). Of all the
health dimensions RE was most frequently
improved, in eight subjects. Slightly more
changes in the mental (24) than in the physical
(20) dimensions were seen. The changes in five
subjects were only in positive direction and in
one subject only in negative direction. In five
subjects, both positive and negative changes
had occurred within the same individual (Tables
3 and 6).

When all the measures, both the physical tests
and the self-rated measures, were interpreted
according to the qualitative SSED approach,
one or more positive change was seen in ten
out of the eleven subjects (Table 6). If the
interpretation claiming double significances
was used, together with the claims on ADL
and HRQOL scores, nine subjects showed
improvement, mostly in one variable each.

Discussion

The present study evaluated TR/HT detailed
and individually. Direct replication with eleven
subjects was used which improves generalizabil-
ity. An effort was made through methodological
rigor and mostly standardized, well-documen-
ted, clinical instruments covering several vari-
ables of the ICF components. Since the MS
population is heterogeneous (Jønsson and Ravn-
borg, 1998), SSED was the appropriate and
possible method of designing this single-center
study. The need for individual evaluation has
been emphasized by Jønsson and Ravnborg
(1998). An added advantage of the SSED was
the complementary, individual measures it gave
access to. However, the measurement occasions
and tests used were plentiful due to the design
and this caused a strain to some of the subjects,
especially during phase B, when the subjects
needed to have the energy to ride after testing.

Single-subject experimental design includes
different techniques of visual analysis, which
constitute a qualitative approach. There were
some problems in interpreting the results due
to lack of absolute decision rules. An approach
claiming both clinical and semi-statistical signifi-
cance of change (two SD band method) regard
only mean changes which can be misleading
(Ottenbacher, 1986). The different possibilities
of approach on interpretation of result in
a SSED can give diverging outcome.

The decisions of clinically important change
are important but quite complex. All the mea-
sures were not covered in the literature (Finch,
Brooks, Stratford and Mayo, 2002) and only a
few reports were specifically of patients with
MS. The limit of 15% was taken from manage-
ment of musculoskeletal conditions (Philadel-
phia Panel, 2001). A corresponding overview
for neurological conditions has not been
reported. The improvements registered in the
present study according to criteria presented,
Table 6. Result summary of the physical tests and self-rated measures for the eleven subjects. Balance changes are shown from phase A1 to B and from B to A2 respectively. The shadow indicates the improvements seen with the approach claiming both clinical and statistical significant changes (the two standard deviation band method).

<table>
<thead>
<tr>
<th></th>
<th>Physical tests (Variable)</th>
<th>Self-rated measures (Variable)</th>
<th>HRQOL (8 dimensions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Subject</td>
<td>A1 to B</td>
<td>B to A2</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>+</td>
<td>No</td>
<td>Normal values</td>
</tr>
<tr>
<td>7</td>
<td>Ceiling effect</td>
<td>Normal values</td>
<td>Normal values</td>
</tr>
<tr>
<td>8</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>9</td>
<td>+</td>
<td>0</td>
<td>0</td>
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<tr>
<td>11</td>
<td>+</td>
<td>+</td>
<td>0</td>
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<tr>
<td>12</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>+</td>
<td>+</td>
<td>Nonwalker</td>
</tr>
</tbody>
</table>

+ = positive change; – = negative change; 0 = no change; No = number; SRLMT = Self-rated level of muscle tension; ADL = activities of daily living; HRQOL = Health-related quality of life.
were sometimes rather small but could nevertheless have an impact on the individual.

The ABA-design implies two possible interpretations when improvements are maintained after the intervention is withdrawn. One is that the change was due to some extraneous factor and the other is that long-term effect is supported (Domholdt, 2000). Different characters of interventions are more or less probable for long-lasting effect. The TR intervention constituted a low frequency, continuous input over ten weeks. The outcome variables of the present study were also of different character and need to be viewed differently when interpreting.

Balance was the variable showing most improvements both during and after intervention. Improvements made were not transient after intervention. Balance is a variable where subjects could successively build capacity and with continuous training keep on improving. According to Pauw (2000), balance improvements could be expected since riding is a balance-demanding task. Several explanations have been proposed (Bertoti, 1988; Heine 1997; MacKay-Lyons, Conway, and Roberts, 1988; MacKinnon et al, 1995). The movements of the horse generate continuous vestibular input, with the rider continually having to adjust to these movements. Righting and equilibrium reactions are thus stimulated and may lead to increased postural control, also through facilitating the musculature of the trunk and extremities. Changes in tempo and direction increase the postural challenge (Heine, 1997). Our results are in contrast to those of a previous MS study (MacKay-Lyons, Conway, and Roberts, 1988), in which no significant balance improvement was seen measured by postural sway. This contrast may be due to differences in measure and design since the intervention seems to have been similar. In the present study, various instruments measuring static and dynamic balance, together with the individualized SSED analyses, achieved a sensitive evaluation, which detected improvements.

Spasticity on the other hand, is a dynamic phenomenon with supposedly transient effect from PT. In a recent TR study of spinal cord patients a short-time effect on spasticity was reported (Lechner et al, 2003). In the present study only one subject showed decreased spasticity during intervention.

The variables rated daily could record short-term changes and daily variations also related to the dates of TR. Opposite to the momentary spasticity ratings performed in a resting position, the SRLMT scale could include other dimensions of muscle tension. The subjects here had the opportunity to depict muscle tone in activity. Sköld (2001) reported a differentiation between Ashworth ratings and self-ratings of spasticity in a population of spinal cord injury patients, who also showed a greater variability in the self-ratings.

The pain-improving result for a few subjects in the present study was interesting, and has not been reported previously. A vast majority of MS patients with chronic pain have back pain due to weaknesses, spasticity, or postural problems (Polman, Thompson, Murray, and McDonald, 2001). Pain was not systematically classified in the present study, but presumably nociceptive pain was affected by the movements in TR rather than neurogen pain.

The ADL improvements seen in four subjects coincided with improvements in balance and the SF-36 dimension RE. Balance and self-confidence are prerequisites to successful performance of ADL. It is important that studies involve aspects of ADL, and deal with abilities of significance to the subject (Jønsson and Ravnborg, 1998; Ko Ko, 1999; Polman, Thompson, Murray, and McDonald, 2001; World Health Organization, 2001). Some subjects had difficulties in stating activities that they had problems with.

Role-Emotional was the SF-36 dimension most often improved; in eight subjects. Improvements in self-confidence, with less fear of movement and position change, have been reported previously (Bertoti, 1988). Psychological well-being was also positively influenced in the study by MacKay-Lyons, Conway, and Roberts (1988). The SF-36 dimension PF was improved in one case only, which possibly reflects less sensitivity to the improvements seen in the physical tests. The result in HRQOL suggests that TR may have different values for different MS patients and that focus should therefore not entirely be on physical indications.

Since several subjects showed baseline values close to normal or ceiling values, a complement of individual measures was useful. The tandem stance, one-leg stance, and functional self-generated perturbations are tests that have been reported elsewhere to discriminate MS patients
from controls and to show higher sensitivity (Frozovic, Morris, and Vowels, 2000). Some subjects in the present study described physical difficulties in the diary despite ceiling effects in the physical tests. This suggests that the tests chosen may not have captured all dimensions. In some of these cases, some improvements were instead seen in the self-rated measurements. More effect detection on the patient-rated measures has previously been described in other MS studies (Fuller, Dawson, and Wiles, 1996; Jones, Lewis, Harrison, and Wiles, 1996; Svensson, Gerdle, and Elert, 1994). As a consequence, a combination of both physical tests and self-rated measures is recommended, which also broadens the evaluation of functioning, disability, and health (World Health Organization, 2001). Yet there is a need for instruments validated in an MS population, suitable for different levels of disability.

The optimum dosage of TR is not known. With TR taking place twice a week for 1 hour each time, improvement in posture was recorded in eight out of eleven children with CP (Bertoti, 1988). The once weekly intervention in the present study, which evaluated an existing clinical practice, was sufficient to bring about some improvements. Patients with MS have a continuous need for training activities to stay as fit and healthy as possible. This life-long need must be met in an individualized manner to maintain patient motivation. Therapeutic riding provides one possibility of supplying training in a context different from the physiotherapeutic department (Bertoti, 1988). In the present study, the attendance rate was 94%. Since all our subjects had been participating in TR at some point before the study start, there was no novelty influence of the intervention, as was speculated in the study by MacKay-Lyons, Conway, and Roberts (1988).

Further effect studies of TR are needed. The multiplicity of symptoms and disabilities in MS makes research complex. To be able to generalize the result to the MS population, a randomized controlled study with a multi-center approach is one possibility of achieving a large enough sample-size.

Conclusion

Ten of the eleven subjects in this study showed some improvement after the once weekly TR-HT intervention. Balance and the SF-36 dimension RE were the variables most often improved. The balance improvement suggests that TR may be suitable for MS patients with balance deficits. Different variables improved for the MS patients and TR can be used to reach different aspects of PT goals. Therapeutic riding provides one possibility of supplying training in a context different from the PT department for MS patients who are in continuous need of supportive rehabilitation.

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