Improving excellence in scoliosis rehabilitation: A controlled study of matched pairs

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Abstract

Objectives: Physiotherapy programmes so far mainly address the lateral deformity of scoliosis, a few aim at the correction of rotation and only very few address the sagittal profile. Meanwhile, there is evidence that correction forces applied in the sagittal plane are also able to correct the scoliotic deformity in the coronal and frontal planes. So it should be possible to improve excellence in scoliosis rehabilitation by the implementation of exercises to correct the sagittal deformity in scoliosis patients. An exercise programme (physio-logic exercises) aiming at a physiologic sagittal profile was developed to add to the programme applied at the centre or to replace certain exercises or exercising positions.

Material and methods: To test the hypothesis that physio-logic exercises improve the outcome of Scoliosis Intensive Rehabilitation (SIR), the following study design was chosen: Prospective controlled trial of pairs of patients with idiopathic scoliosis matched by sex, age, Cobb angle and curve pattern. There were 18 patients in the treatment group (SIR + physio-logic exercises) and 18 patients in the control group (SIR only), all in matched pairs. Average Cobb angle in the treatment group was 34.5° (SD 7.8) Cobb angle in the control group was 31.6° (SD 5.8). Age in the treatment group was at average 15.3 years (SD 1.1) and in the control group 14.7 years (SD 1.3). Thirteen of the 18 patients in either group had a brace.

Outcome parameter: average lateral deviation (mm), average surface rotation (°) and maximum Kyphosis angle (°) as evaluated with the help of surface topography (Formetric-system).

Results: Lateral deviation (mm) decreased significantly after the performance of the physio-logic programme and highly significantly in the physio-logic ADL posture; however, it was not significant after completion of the whole rehabilitation programme (2.3 vs 0.3 mm in the controls). Surface rotation improved on average 1.2° in the treatment group and 0.8° in the controls while Kyphosis angle did not improve in both groups.

Discussion: The physio-logic programme has to be regarded as a useful ‘add on’ to Scoliosis Rehabilitation with regards to the lateral deviation of the scoliotic trunk. A longitudinal controlled study is necessary to evaluate the long-term effect of the physio-logic programme also with the help of x-rays.

Keywords: Idiopathic scoliosis, rehabilitation, physiotherapy, schroth programme, physio-logic programme

Introduction

Thoracic flatback has been assumed to be the triggering factor for thoracic Idiopathic Scoliosis [1–5]. So, if coupled rotation and lateral deviation of the spine are secondary patterns of deformity in the development of Idiopathic Scoliosis (IS), it should be possible to correct or improve scoliosis by the application of sagittal forces.

Flatback seems to be a major problem in the treatment of patients with idiopathic scoliosis using braces. It has been demonstrated that flatback may be increased instead of corrected using several bracing concepts [6]. There are also other studies to support especially the Boston brace to reduce sagittal curvatures of the spine and in a Pub Med search no study has been found to support the opposite. Boston braces, the Charleston bending brace and most of the other types of scoliosis braces up to now have no pressure points to address the sagittal profile while in the last modifications of the original Chêneau brace pressure points for the correction of thoracic hypokyphosis were introduced [7].

Physiotherapy programmes so far mainly address the lateral deformity of scoliosis [8–11], a few aim at the correction of rotation [12–15] and only very few address the sagittal profile [16–18], although already before 1992 Negrini stated that the sagittal deformation is also important to correct with the help of exercises [19]. In some programmes, flatback is addressed in extent; however, those programmes failed to show good results [20]. All patients...
in the treatment programme described got worse within 1 year of regular treatment. So it seems not reasonable to mobilize the scoliotic spine into a global kyphosis.

In the Schroth programme, thoracic kyphosis is addressed performing a special breathing technique (Figure 1); however, in the exercising position the flatback is clearly visible (Figure 2). The results of the Schroth concept seem to be quite good and show that progression can be prevented in many cases [21–25]. So, the Schroth programme has developed to be the gold standard of physiotherapy for the treatment of scoliosis in many countries as well as for Scoliosis Intensive Rehabilitation (SIR) [18].

Meanwhile, there is evidence that correction forces applied in the sagittal plane are also able to correct the scoliotic deformity in the coronal and frontal planes [6]. In an experimental study comparing the short time effect of two different braces it could be shown that sagittal correction forces lead to similar short-term corrections as can be measured with the help of surface topography, as the 3D correction brace at the moment gold standard in many European countries.

Although the Schrot method addresses also the sagittal plane in the long-term [17], the results achieved in the experimental study lead to the idea to improve excellence in scoliosis rehabilitation by the implementation of exercises to correct the sagittal deformity in scoliosis patients more powerfully. An exercise programme was developed aiming at a physiologic sagittal profile to add it to the programme applied at the centre or to replace certain exercises or exercising positions. The exercises of this programme all have the same basic principle to increase and so improve lumbar lordosis at L2 level and lower thoracic kyphosis and are called physiologic® exercises. However, to finally implement it to SIR it should first be shown to be effective in the short-term.
Materials and methods

To test the hypothesis that physio-logic exercises improve the outcome of SIR, the following study design was chosen: Prospective controlled trial of pairs of patients with idiopathic scoliosis matched by sex, age, Cobb angle and curve pattern. Outcome parameter: average lateral deviation (mm), average surface rotation (°) and maximum Kyphosis angle (°) as evaluated with the help of surface topography (Formetric®-system).

Treatment group

In July 2004, 20 consecutive patients with adolescent idiopathic scoliosis between 13–17 years old were asked to take part in the study. They were all females and were admitted regularly for an inpatient rehabilitation programme of minimum 4 weeks. All 20 patients and their parents agreed to take part in the study. Curve magnitude (Cobb angle) and curve pattern (King classification) were recorded.

The patients of this group had a regular inpatient rehabilitation programme as prescribed and additionally in the second or third week of their 4-week-programme five times 90 minutes of the new exercise programme called physio-logic®. The experimental design was arranged in a fashion that all the subjects in either subject group had similar exercise hours/day. There might have been different responses among the subjects in the physio-logic® group as the subjects had different periods of the intervention of the physio-logic exercises (either at the 2nd or 3rd week of the programme); however, as is needed 20 subjects with certain inclusion criteria given to be treated during the same time as the control group saw no other way to perform this study.

For this study group, surface topography was performed before and after the 4-week-programme as usual and additionally directly after the performance of the 1-week physio-logic® programme. Additionally to that, the physio-logic® ADL posture trained at that week was tested with the help of the Formetric surface topography system as well.

Control group

To be able to establish a control group of biggest homogeneity possible, one chose to take the matched pair technique. One was looking for another 20 patients having inpatient rehabilitation at the same time before applying physio-logic® exercises for the treatment group. The patients of the control group were matched by age, curve magnitude and curve pattern in a way that in the end for every patient from the treatment group had another patient in the control group of similar curve pattern, curve magnitude (±5°) and age (±1 year). All patients in either group were female.

While the treatment group had the Schroth inpatient rehabilitation programme as routinely performed at the centre and an additional week with 90 minutes of physio-logic exercises per day, the control group only had the Schroth inpatient rehabilitation programme as described in literature [18]. As usual, the control group was investigated by use of surface topography before and after rehabilitation.

During the first 2 days performing the physio-logic® programme two of the patients from the treatment group cancelled their attendance. Therefore, the patients were also removed from the control group matched individually. In the end, there were 18 patients in the treatment group and 18 patients in the control group as well all in matched pairs. Average Cobb angle in the treatment group was 34.5° (SD 7.8) Cobb angle in the control group was 31.6° (SD 5.8). Age in the treatment group was at average 15.3 years (SD 1.1) and in the control group 14.7 years (SD 1.3). Thirteen of the 18 patients in either group had a brace.

Scoliosis intensive rehabilitation (SIR)

SIR employs an individualized exercise programme combining corrective behavioural patterns with physiotherapeutic methods, following principles described by Lehnhrt-Schroth [12]. The three-dimensional scoliosis treatment is based on sensor-motor and kinesthetic principles and its goals are (1) to facilitate correction of the asymmetric posture and (2) to teach the patient to maintain the corrected posture in daily activities.

Referrals are from spine centres, general orthopaedic surgeons, paediatric physicians and general practitioners. A 4-week minimum stay is required for the first treatment and may be up to 6 weeks, depending on prognosis; return treatments are 3–6 weeks in length, depending on symptoms and prognosis. Patients are admitted in groups, with the first day of the programme devoted to diagnosis and evaluation of the three dimensional deformity, supervised by seven staff physicians (one orthopaedic surgeon and six general practitioners or specialists for Physical Medicine and Rehabilitation) who also provide oversight for each patient’s programme. On the second day, instruction in basic human anatomy, spinal deformity and principles of postural balancing therapy is provided to the group. Each patient receives a detailed summary of his/her own condition and those with matching diagnoses (based on age, degree and pattern of curvature) work together in groups. Evening and weekend social activities provide a sense of community and foster
development of psychological support systems that can be maintained after treatment is complete.

The treatment programme consists of correction of the scoliotic posture with the help of proprioceptive and exteroceptive stimulation and begins on the third day after admission. Each weekday, after a 20-minute group warm-up session, the patients exercise in matched groups for 2 hours in the morning and 2 hours in the afternoon and receive shorter more individual training sessions in between. Central to the individual and group exercise programmes is therapist assistance, by a staff of 20 physical therapists and sports therapists who supervise all exercises and provide exteroceptive stimulation needed to obtain desired correction. Depending on individual curve patterns, the patients are assigned to special exercise groups for an additional 2 hours daily. Development and maintenance of the corrected posture is facilitated using asymmetric standing exercises designed to employ targeted traction to restore torso balance and mobility.

The correction is supported by 'rotational breathing' exercises, an integral part of the regime: By selective contraction of convex areas of the trunk, the inspired air is directed to the concave areas of the chest and the ribs to lengthen and mobilize soft tissues in these regions. Female patients wear bikini tops during all sessions and ceiling and wall mirrors enable the patients to self-monitor progress at all times during standing and floor exercises; this practice facilitates optimum correction during exercises and fosters patient proprioception of a balanced posture. Four full time massage therapists provide bi-weekly mobilization therapy for each patient, using myofascial release, manual traction, ischemic pressure and pressure point therapy. Two full-time respiratory therapists meet weekly with each patient to monitor vital capacity and to provide training in corrected breathing patterns. Psychological counselling is provided by two staff psychologists to help patients cope with feelings about the diagnosis of deformity as well as the impact of treatment, as needed; patients can request individual psychotherapy in response to anxiety, depression or other psychological distress. Optional evening group sessions devoted to relaxation therapies including meditation and visualization approaches are also available. Osteopathic manipulation and acupuncture by staff therapists are available to treat pain as needed, upon request by the patient.

At the end of in-patient treatment, the primary goal is for patients to be able to assume their personal corrected postural stereotype, independent of the therapist and without mirror control and to maintain this position in their daily activities. Recommended at-home follow-up treatment includes three to four exercises for 30 minutes daily in order to maintain the improved postural balance. Therapists throughout Germany receive training in the Schroth Clinic approaches so that local outpatient resources are available to patients after discharge. In case of pain, curvature progression or pulmonary symptom development repeat SIR treatment is available by referral from primary care physicians.

The physio-logic\textsuperscript{®} exercise programme

Within the physio-logic\textsuperscript{®} exercise programme, one provides

1. Symmetric mobilizing exercises to improve lording mobility of the lumbar spine and kyphosing mobility of the thoracic spine;
2. Asymmetric exercises to improve postural corrections also in frontal and coronal plane; and
3. The physio-logic\textsuperscript{®} ADL posture

The symmetric mobilizing exercises are performed repeatedly. Those exercises can only be performed with the help of postural reflexes. First, lumbar lordosis is empowered actively and the pelvis is tilted forward while the upper trunk is reclined backwards to improve thoracic kyphosis reflectorily.

It is not the aim of the exercises to increase lumbar lordosis at the L5/S1 level for this region is responding with unspecified low back pain when stressed. Therefore, one aims at a lordosis at the L2 level. One can enforce the exactness of the exercise by ventralizing the lower ribs (Figure 3).

For the asymmetric postural correction in 3D, one can use exercises from the Schroth programme modified due to the principles of the physio-logic\textsuperscript{®} exercise programme (Figure 4).

Activities of daily living (ADL) are very important to change postural stereotype and for this reason the physio-logic\textsuperscript{®} ADL posture is trained in standing and walking (Figures 5 and 6). Therefore, the patients are trained to perform the ‘Catwalk’ which includes the basic principles of the physio-logic\textsuperscript{®} programme addressing the sagittal plane (Figure 5) and the ADL (Activities of daily living) posture called ‘Nuba’-position. This position is derived from the normal upright standing and walking position the Nuba (people from North Africa) perform usually.

Actually there is no angle and possible range of thoracic kyphosis and lumbar lordosis defined to perform or maintain in the physio-logic\textsuperscript{®} exercises. Muscle groups involved for the exercise action are not identified yet. This might be subject to further investigation.

Surface topography system used for this study

The print-out of the Formetric\textsuperscript{®}-system itself gives a lot of values, the most important are the
Figure 3. Left: Lordosing exercise with the risk of low back pain due to L5/S1 stress. Right: Ventralization of the lower ventral ribs to improve Lordosis at L2 level, where it naturally belongs [http://www.leni-riefenstahl.de/eng/dienubav1.html]. In this position L5/S1 stress is reduced.

Figure 4. Schroth exercise (see also Figure 2) changed to physio-logic\textsuperscript{®} style. Lumbar lordosing and thoracic with increased kyphosis.
Figure 5. Physio-logic® ADL posture in standing position. Lumbar lordosis is increased, pelvis is corrected to the opposite side of deformity while the hand on the lumbar hump helps to redress the lumbar curve. It is also possible to redress the ventral ribhump with the other hand (right).

Figure 6. Catwalk’ with the patients from the treatment group. Ventralizing the lower ribs is important to reduce L5/S1 stress and so the possibility of low back pain.
following: Lateral asymmetry, surface rotation and kyphotic angle.

In the video rasterstereography (Formetric\textsuperscript{®}-system), the whole object is illuminated by a pattern of parallel lines, recorded in a single frame and needing only a short measurement time (40 milliseconds). The automatic image processing consists of the identification of the raster lines and automatic 3-D reconstruction of the back; shape analysis is performed by a mini computer. The computer helps to evaluate the spine with the assistance of triangulation [26, 27]. The video rasterstereography (Formetric\textsuperscript{®}-system) has a point discrimination of 0.15 mm and in a typical case of measurement 25,000 surface points are calculated (Figure 7).

Parameters used to compare the short-term effects of the different treatment concepts described were average lateral deformation (root mean square, rms) with a technical error of 3 mm, average surface rotation (rms) with a technical error of 1.5° and average kyphosis angle with a technical error of 2.5° as measured and calculated by the Formetric\textsuperscript{®} surface topography system [28–30].

The surface topography values for the treatment group were compared as follows: The values after the treatment were compared with respect to the first value before treatment as were the values directly after performing the physio-logic\textsuperscript{®} programme and in the physio-logic\textsuperscript{®} ADL position. In the control group, the pre-treatment values were compared to the post-treatment values in the same way. The surface topography values were compared statistically using Winstart\textsuperscript{®} Software.

**Results**

The Formetric\textsuperscript{®} values Lateral Deviation in mm, Surface Rotation in ° and Kyphosis Angle in ° before Scoliosis Intensive Rehabilitation (SIR), after SIR, after 5×90 minutes performing the physio-logic\textsuperscript{®} programme (PL) and in the physio-logic\textsuperscript{®} ADL position (ADL) for the treatment group as well as for the control group can be seen in Table I.

The difference between Lateral Deviation before/after SIR, before SIR/after performing the physio-logic\textsuperscript{®} programme (PL) and before SIR/in the
The only significant change in the control group was the improvement of Surface Rotation (\(0.75\), \(p = 0.015\)) compared to the improvement before/after SIR (\(-1.2\), \(p = 0.1\)) which, however, was not significant (Figure 9).

Interestingly, the physio-logic\(^{\circledR}\) programme itself did not have an impact on Surface Rotation directly after the programme was applied in the physio-logic\(^{\circledR}\) ADL position. However, Lateral Deviation was changed significantly in the treatment group compared to the control group. Kyphosis Angle was only changed slightly with a tendency to decrease instead of the expected increase (Figure 10).

### Discussion

Video rasterstereography (Formetric\(^{\circledR}\)-system) has been used for the evaluation of brace and physiotherapy effects [31–35]. Although there are certain limitations to respect, it has been demonstrated that certain exercises tend to improve scoliosis as well as kyphosis in the short-term [32–35]. While in Scheuermann’s kyphosis the degree of curvature decreased significantly after in patient rehabilitation [34], there is no evidence for the short-term effect of exercises on the flatback related to IS [32, 33, 35]. However, there is evidence that the Schroth physiotherapy programme as well as the Chêneau brace are able to correct thoracic flatback in the long-term [17, 31].
In this study, Lateral Deviation was significantly improved in the treatment group (SIR + physio-logic®), especially directly after the performance of the physio-logic® programme and in the physio-logic® ADL position. The control group (SIR) showed no significant changes.

In the preceding studies, Surface Rotation did not change significantly [32, 33]; however, in the control group significant improvements were found which, however, were lower than in the treatment group but in this group not significant.

Kyphosis Angle decreased in both groups, significantly in the treatment group and not significant in the control group although the physio-logic® programme aims at an increase of thoracic kyphosis, as can be seen in Figures 3–6. The hypothesis is that in the development of IS the sagittal deformity comes first and though is the stiffest component of the 3D deformity. Secondly, trunk torsion appears which is also more stiff than lateral deformation that seems to be the least stiff part of the 3D deformity and so in the short-term the best correctable. This theory is supported in a controlled study by the fact that it is possible to correct flatback reflectorily in short-term. Treatment and control group showed changes in the same direction.

Either subject group itself was not totally homogenous. Some subjects were under a mixture of brace treatment and physical exercise treatment but some were with physical exercise treatment only. During SIR, the braces are worn in the evening and during night time, while during daytime there are exercises to be performed for ∼6 hours.

As the proportion of patients with a brace was the same in both groups, brace wearing should not have an influence on the results. Rigo et al. [35] recognized that brace treatment does not affect the results of the 4 weeks exercise programme obtained with the Formetric®-system.

It has been emphasized that brace loads are not applied in an optimal way to correct the 3-D deformities associated with thoracic idiopathic scoliosis and that loads applied on the posterior rib hump should be re-equilibrated to reduce anterior displacement of the trunk [36]. This is what has been found in an experimental study as well where it has been demonstrated that a brace designed to correct sagittal profile may only also correct scoliosis in 3D [6]. So the same principles seem reasonable to be applied in postural re-education and correction using exercises as well.

From experience, one has no explanation for the fact that hypokyphosis in the short-term could not be corrected by the physiotherapy programmes described, although both apply a 3-point pressure in the sagittal plane. The same applies for braces correcting the sagittal planes directly [6]. The hypothesis is that in IS the sagittal deformity is the primary problem. This theory is supported by quite a number of studies [1–4, 37]. The deformity in the sagittal plane, though, may be the stiffest and, therefore, not as easy to correct as the deformities in the other planes.
Conclusions

The physio-logic® programme has to be regarded as a useful ‘add on’ to Scoliosis Intensive Rehabilitation (SIR) with regards to the lateral deviation of the scoliotic trunk. The physio-logic® ADL position corrects lateral deviation of the scoliotic trunk not only highly significant but also on average more than the technical error of the measuring system and so should be trained regularly during SIR.

A longitudinal controlled study is necessary to evaluate the long-term effect of the the physio-logic® programme also with the help of x-rays.

References


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