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Research article

EFFECTS OF THE SCHROTH METHOD IN CHILDREN WITH IDIOPATHIC SCOLIOSIS

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**Bojan Jorgić¹, Petra Mančić¹, Saša Milenković¹,
Nikola Jevtić², Mladen Živković¹**

¹Faculty of Sports and Physical Education, University of Niš, Niš, Serbia

²Scolio Center, Novi Sad, Serbia

Abstract. *Scoliosis is a multifactorial three-dimensional (3D) spinal deformation which always includes elementary deformations on three planes: a lateral curvature on the frontal plane, loss of natural physiological curvature on the sagittal plane and, in most cases, increase of lordosis in the lumbosacral joint (hyperlordosis), and a (very typical) vertebral axial rotation on the horizontal plane. One of the best methods in scoliosis correction is the Schroth method. In view of the above, the objective of this study is to identify the effects of the Schroth method on correcting functional-motor status in children with adolescent idiopathic scoliosis (IS). The sample of participants comprised 20 children, of an average age of 14.5, who took part in the 10-day Schroth Camp. The following measuring instruments were used for the assessment of the effect of the Schroth method: the Sorensen test, the Sit-and-reach test, and height assessment. Statistically significant improvements were identified across the results of all three tests, for the Sorensen test: 45.6 ± 19.29 s, the Sit-and-reach test: 4.05 ± 2.25 cm, and height 1.4 ± 0.66 cm. It can be concluded that the conducted Schroth method exercise program exerted a positive effect on improving motor functionality, as well as enhancing flexibility and isometric endurance of the lumbar extensors of the spine. Additionally, there was an increase in height, which indicates a positive effect in terms of the functionality and symmetry of the left and right sides of the body, and in terms of improved posture on the frontal and sagittal planes.*

Key words: *flexibility, muscular endurance, lumbar extensors*

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Corresponding author: Bojan Jorgić

University of Niš, Faculty of Sport and Physical Education, Čarnojevića 10a, 18000 Niš, Serbia

Phone: +381 18 510900 • E-mail: bojan.jorgic@fsfv.ni.ac.rs

INTRODUCTION

Postural disorders in children can be localized on the following segments of the body: the spinal column, the chest, legs, and feet (Živković, 2009). Deformities of the spinal column are all deviations of the curvature of the spinal column from the normal physiological curvatures. In registering the deviation, the plane on which the deviation occurs is identified, as well as the part of the spinal column, the extent of deviation, the degree to which it is possible to reduce the deformity, as well as the position of the pelvis in relation to the other parts of the locomotor apparatus. These deformities are frequently accompanied by foot deformities. The consequence is bad posture, due to uneven distribution of pressure to the vertebrae, leading to structural changes in them (Vulović, 2009). A fundamental characteristic of the locomotor apparatus is the principle of symmetry and balance. Depending on which oscillations in the relation of muscle group symmetry and balance occurred, different forms of postural disorders emerge (Milenković, 2007). The most frequent disorders are: kyphotic, lordotic, and scoliotic bad posture. Disorders of the symmetry and balance of trunk muscles, located to the left and right sides of the spinal column, contribute to the occurring of “scoliotic bad posture,” or “scoliosis” (Milenković, 2007). This very phenomenon of the omnipresent bad body posture and body deformities poses the need to dwell on this topic and engage the attention of scientists working in different fields (pedagogues, physical education teachers, orthopedics specialists, sports medicine physicians, ergonomics-related practitioners, etc.) both in the area of prevention and treatment (Purenović, 2007).

Scoliosis is a multifactorial three-dimensional (3D) spinal deformation which always involves elementary deformities along three planes: lateral curvature on the frontal plane, loss of natural physiological curvature on the sagittal plane, with a decrease of thoracic kyphosis in the chest area (emergence of hypokyphosis) and in most cases an increase in lordosis in the lumbosacral joint (emergence of hyperlordosis), and a (very typical) vertebral axial rotation on the horizontal plane (Dubosset, 1994). Based on the cause, scoliosis is most frequently classified as primary idiopathic scoliosis (IS) and secondary scoliosis (Cassar-Pullicino & Eisenstein, 2002; Kim et al., 2010).

IS comprises the most frequent type of scoliosis, occurring in 80% of cases. It is a 3D spinal deformity, with curvature on the frontal plane, with a minimum Cobb angle angulation of 10° , curvature on the lateral plane, and vertebral rotation and deformation of unknown origin (Stokes, 1994). It also affects deformation of the thorax, with attendant thoracic cavity rotation, protrusion of ribs and shoulder blades, shoulder height inequality, pelvic deformation and drop, leg length inequality (Cassar-Pullicino & Eisenstein, 2002).

Adolescent idiopathic scoliosis (AIS) occurs between the ages of 10 and 18, with statistics indicating right scoliosis more prevalent during this life stage than left scoliosis. There is a high predominance of AIS in girls, who feature more pronounced curvature compared to boys. The risk of scoliotic progression is related to growth potential and the size of the initial curvature. Scoliosis may lead to psychological issues in children, as well as pain, respiratory complications, and limited functionality. The negative effects typically manifest when the curve exceeds 30° . It is less likely for curves lesser than 30° to progress after skeletal maturity. For this reason, early treatment is recommended during growth in puberty in order to prevent scoliosis from progressing (Schreiber et al., 2016). Its etiology is unknown. Vertebral bodies grow at a faster rate than posterior elements, which primarily leads to lordosis. Decreased dorsal growth hinders the vertical growth of ventrally located vertebral bodies, forcing them to rotate in order to make room for their position. This leads

to rotational lordosis. These findings date from 1952. Many recent studies have corroborated this idea, and demonstrated that the spinal canal is shorter than the anterior ligament of vertebral bodies. In addition to the difference in anterior-posterior growth, there is also 3D deformation of the bodies of the vertebrae (Hefti, 2013).

One of the methods employed in the treatment of scoliosis is the Schroth method. It is a non-surgical therapy applied in correcting scoliosis, with a very long tradition. The corrective treatment based on the principles of the Schroth method is applied very frequently due to its approach to the problem, based primarily on three-dimensional breathing, which has the most significant role in the treatment of scoliosis (Jevtić, 2014). The basic objective of this treatment is to enable the patient to maintain correct posture solely through the activation of trunk muscles. The Schroth method emphasizes postural correction throughout the day in order to alter the usual positions and improve alignment, reduce pain, and progression. The main advantage of this programme lies in its incorporation in normal everyday activities with a view to changing the asymmetric stress on the body, thus reducing progression and pain (Berdishevsky *et al.*, 2016). By applying this method, the progression of the curvature is halted and its correction is achieved, patient quality of life is enhanced, posture is improved, vital lung capacity is increased, and the patient is enabled to maintain the achieved correction. It has been proven clinically that daily exercises based on this method for a duration of 30 to 120 minutes inhibit the mechanical forces occurring due to poor posture and gravity. In this way, the further increase of the curvature over time is prevented (Zaborowska-Sapeta, Kowalski, Kotwicki, Protasiewicz-Fałdowska, & Kiebzak, 2011).

The author of the Schroth method is Katharina Schroth, born in Dresden, Germany, in 1894, who herself suffered from scoliosis. She came up with the original idea by observing a rubber ball with a depression which could be corrected under pressure from air. The depression on the ball reminded her of the concave portion of her body, so she began to breathe so as to fill the collapsed side of her body with air, and thus arrived at the conclusion that her posture was improving. It was on the basis of this thinking that the subsequent method of rotational breathing was developed. Schroth also observed that, along with the translation, axial rotation, and collapse of the spine, different anatomical structures of the trunk are also subject to translation, axial rotation, and collapse, one opposite the other, in line with the spine (Lehnert-Schroth, 2007).

Positive effects of the application of the Schroth method in children with scoliosis have to date been identified pertaining to enhanced vital capacity (Weiss, 1991; Jevtić *et al.*, 2017b), reduced Cobb angulation, and body weight redistribution on the concave and convex side of the scoliosis (Kim & Hwang, 2016), and muscular strength (Otman, Kose, & Yakut, 2005). In accordance with the above, the aim of this study was to determine the effects of intensive Schroth treatment on correcting functional motor status in children with IS.

METHODS

The sample of participants

The sample of participants comprised 20 participants aged 9 to 18 who took part in the “International Schroth Scoliosis Therapy-*ISSST* Schroth Camp” held in Novi Sad over 10 days, between February 1-10, 2018. All participants had been diagnosed with IS, with varying types of scoliotic curvature.

The sample of measuring instruments

The following measuring instruments were used at the initial and final measurements of this study:

1. Height measurement (BH) in cm;
2. Sorensen test (ST) in s;
3. Sit and reach test (SRT) in cm.

Height was measured in accordance with the recommendations of the International Biological Program (IBP), designed by Weiner and Loyrie in 1969 (Đurašković, 2001). For measuring height, the “GMP Swiss” anthropometer was used, with a measurement precision of 0.1 cm.

The Sorensen test was used in order to assess isometric endurance of the lumbar extensor muscles. This test measures how long the participants' lumbar muscles can support isometric contraction. The maximum duration for lumbar muscle isometric contraction is up to 240s, after which time the test is stopped as a precaution. The test is conducted on a bench, with the participant in a prone position engaging in trunk extension, while the test is controlled by two therapists. One therapist holds the participant's lower extremities, while the other supervises the precision of the test and keeps time. On the therapist's signal, time keeping begins, and the participant assumes the position described above. The participant is warned about any deviation (movement, rotation) from the position described above. After two warnings, the testing is stopped. After the completed test, time is measured in seconds, with a precision of 0.1s (Moffroid, 1997; McGill, Childs, & Liebenson, 1999; Jevtić, Marinković, Javorac, Semeredi, & Obradović, 2015).

For the assessment of flexibility, the “sit and reach” test was used. The test includes the participant sitting with outstretched legs, resting their feet flat against a specially constructed box which has a ruler attached to its horizontal side (across the middle). The legs have to be completely stretched, with no bending of the knees (the heel, the calf, and the back of the thigh all need to be touching the surface). The participant's task is to move the movable slider along the ruler with the tips of their fingers, while bending as far forward as possible (long sitting hamstring stretch). Reaching the end position, it is necessary to hold for about 2 s. The length of the reach is measured (in cm), measured as the distance from the edge of the bench to the position of the slider (the fingertips) (Castro-Piñero et al., 2009). All testing was conducted in accordance with the standards of the 2008 Helsinki Declaration on the Ethical Principles for Medical Research Involving Human Subjects (World Medical Association, 2011).

Description of the experimental treatment

The “ISST Schroth Camp” experimental program lasted 10 days, and was aimed at children aged between 9 and 18 affected with kyphosis and scoliosis. The treatment comprised Schroth exercises exclusively, and was provided by licensed Schroth therapists. The camp was founded in 2014 in Serbia, but is currently administered in other countries as well (Serbia, Croatia, Bulgaria, Romania, and Canada). The treatments were conducted over four and a half hours every day, namely three sessions of an hour and a half intercut with one and a half hour breaks. The patients were divided into four groups based on the type of curvature. Each patient obtained a set of 8-12 exercises. Applying the

exercises achieved counter-flexion of the scoliotic curve on the frontal plane, derotation on the axial plane, and re-kyphotization, or re-lordotization, on the sagittal plane. On the fourth and eighth days, the third exercise cycle was substituted with a therapeutic massage or a visit to the swimming pool. The first and last days were designated for conducting tests.

Description of the Schroth method

The first schematic representation of scoliosis was provided by Schroth (the scheme of scoliosis with three curves). In that scheme, the trunk is divided into three imaginary segments (Lechnert-Schroth, 2007): the Cervical spine, along with the shoulders and head; the Thoracic spine with the chest cavity; and the Lumbar spine with the pelvis.

In scoliosis, these three imaginary segments axially rotate, collapse into concave zones, and dislocate in relation to one another. In the case of dextro-convex scoliosis, the principal thoracic segment rotates and subluxates to the right, collapsing on the left. The upper segment rotates and subluxates to the left, collapsing on the right side, like the lower lumbar-pelvic segment. These segments subluxate laterally and rotate opposite each other (Rigo *et al.*, 2008).

Katharine Schroth's daughter, Christa Legnert-Schroth, later described a scoliosis scheme with four curves, recognized nowadays as well. The Schroth classification system derives from the Schroth principle of dividing the body into "Body Blocks". This symbolic description helps to explain scoliotic changes as compensatory adaptations. Body blocks present the deformation of the body as a change in its geometric form, from a rectangle into a trapezoid shape. The lateral shift and rotation, as well as compression on the concave side and expansion on the convex side, are clearly visible. In a standing static position, the body blocks need to align perpendicularly to their center of gravity in the central sacral line (Berdishevsky *et al.*, 2016).

The classification system of the Schroth method provides the direction of lateral deviation and rotation of the principal body blocks (the main curvatures), as well as clear guidance for a standardized treatment plan, including a therapy diagram, home-exercise program, and the necessary mobilizing technique. According to the Schroth method system of classification, the different types of scoliosis always begin with the main curvature, and are followed by the relevant secondary curves.

The Schroth system of classification for the scoliotic curvature derived from the Schroth principle of dividing the body into "body blocks" is presented anatomically (A) and schematically (B). Scoliosis leads to body blocks' deformation, by changing their geometric shape from a rectangle (B) to a trapezoid (C). A patient with a major lumbar scoliosis left convex curve features a lumbar block shifted to the left, while the hip-pelvic block shifts to the right (D) (Berdishevsky *et al.*, 2016).

Within the Schroth method, there are five pelvic corrections which are assumed, that is, which need to be performed prior to proceeding on to the main principles of the correction. These first five principles ensure that the pelvis re-aligns, or balances, with the trunk in the optimal manner before the principal corrections. The five principles are as follows: Axial elongation; Deflection; Derotation; Rotation and breathing; Stabilization.

During the application of these principles, the patient is taught how to reduce (remove) the concavity of the trunk, and to reduce prominence (Berdishevsky *et al.*, 2016).

The objectives of the Schroth method are the same for individual and group treatments (Berdishevsky et al., 2016), and pertain to: proactive spinal correction so as to avoid surgery, postural practice so as to halt or decrease progression, providing information as support to the process of providing instructions, instructing the patients on how to perform the exercise program at home, providing support to the patients for self-help, and a strategy for pain prevention and management.

Statistical analysis

All the results obtained are represented using descriptive statistical parameters (mean, standard deviation, maximum and minimum result, and range). In order to determine the difference between the initial and final measurements, the dependent t-test was used. The data was processed using the statistical software SPSS, IBM Corp. Released 2010. IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.

RESULTS

Table 1 Descriptive statistics

Variables	Range	Min	Max	Mean	SD	Sig. (K-S)
BHI (in cm)	38.00	133.00	171.00	161.25	9.41	.259
BHF (in cm)	38.60	134.50	173.10	162.65	9.55	.285
STI (in s)	226.00	75.00	301.00	174.90	50.60	.910
STF (in s)	224.00	136.00	360.00	220.50	51.63	.866
SRTI (in cm)	15.00	.00	15.00	4.45	3.87	.178
SRTF (in cm)	18.00	2.00	20.00	8.50	4.61	.359

Legend: BHI-initial results of height measurement, BHF-final results of height measurement, STI-initial results of Sorensen test, STF-final results of Sorensen test, SRTI-initial results of Sit and reach test, SRTF-final results of Sit and reach test, SD-Standard Deviation

Table 1 presents the results for descriptive statistics for the tested variables at the initial and final measurements. The results of the Kolmogorov-Smirnov test indicate no statistically significant deviation of the distribution of the results.

Table 2 The results of the t-test for repeated measurements

Variables	Paired Differences					
	Mean	SD	T	df	Sig.	Effect size
Pair 1 BHI-BHF	-1.40	0.66	-9.490	19	0.00	0.83
Pair 2 SRTI-SRTF	-4.05	2.25	-8.018	19	0.00	0.77
Pair 3 STI-STF	-45.60	19.29	-10.568	19	0.00	0.85

Legend: BHI-initial results of height measurement, BHF-final results of height measurement, STI-initial results of Sorensen test, STF-final results of Sorensen test, SRTI-initial results of Sit and reach test, SRTF-final results of Sit and reach test, SD-Standard Deviation

The results in Table 2 indicate that there has been a statistically significant improvement of results regarding height, flexibility, and isometric endurance of lumbar extensors at the significance level 0.00. This is also indicated by the height values for effect size (0.83, 0.77 and 0.85)

DISCUSSION

The study conducted included participants of an average age of 14.5, where the youngest participant was 9, and the oldest one 18. Regarding the number of study participants, 16 were girls, while 4 were boys. The results thus obtained in the study conducted are in accordance with other studies which also found a greater incidence of AIS in females than in males (Jelačić, Villagrasa, Pou, Quera-Salvá & Rigo, 2012). Several of the following studies determined the incidence ratio for boys and girls, respectively. A 1975 study found the ratio between girls and boys to be 1.2:1, in favor of the female sex (Brooks, Azen, Gerberg, Brooks, & Chan, 1975). A more recent study, from 2000, calculated the ratio at 3.8:1 (Al-Arjani, Al-Sebai, Al-Khawashki, & Saadeddin, 2000).

The principal objective of the present study was to determine the extent of the effect of the program applied on changes in functional and motor status in children with IS. The results demonstrate that, in (nearly) all study participants, there was an improvement of isometric muscle strength of lumbar extensor muscles in the final testing compared to the initial one. The results improved by 45.6 ± 19.29 (mean \pm SD), in seconds. This indicates that the Schroth method plays a vital role in increasing trunk extensor muscle strength, thus enhancing the isometric strength of trunk lumbar extensor muscles. Moreover, there was an increase in muscle flexibility in the lumbar segment of the spinal column, by 4.05 ± 2.25 (mean \pm SD) cm, which is normally, due to scoliotic bad posture, tight (shortened) as a result of reduced elasticity and flexibility. Jevtić et al. (2017a) found a positive effect of applying the Schroth method on increasing flexibility and endurance of muscles in the lumbar region. Compared with the results of the present study, this is another confirmation of the efficiency of this method in treating scoliotic bad posture.

Additionally, one of the consequences of scoliosis is the so-called lumbar syndrome, that is, lower back pain. Back pain is rather frequent in adolescents, especially in girls. The relation between IS and lower back pain has not yet been sufficiently researched; however, there is no doubt that some patients with AIS experience lower back pain (Balague & Pellisé, 2016). Nevertheless, the pain does not seem to present a major problem for a vast majority of adolescents with an idiopathic type of this deformity. In most studies, the pain did not correlate strongly with the Cobb angle, with a much greater difference between the sexes in terms of scoliosis incidence compared with the epidemiological data on back pain. All of the above seems to favor a greater etiological role of adolescent IS deformity in back pain (Balague & Pellisé, 2016). In adults, the influence of pain in scoliosis is entirely different. In order to understand lower back pain in adults with scoliosis, Kostuik and Bentivoglio (1981) conducted a study which concluded that, the greater the degree of curvature, the greater the severity of the pain, especially regarding curvatures greater than 45 degrees. Patients with no back pain had smaller curves (Kostuik & Bentivoglio, 1981). Considering these results, it is purported that prevention in youth is very important, in order to avoid both a later progression of the curve and pain in the lumbar back area.

Accordingly, the results have demonstrated that applying the Schroth method plays a significant role in improving the everyday functioning of children with IS in terms of enhanced flexibility and endurance of lumbar extensors, which indirectly has an effect on the prevention and reduction of lower back pain. In accordance with the obtained results, Lee et al. (2016) identified a positive effect of the Schroth method on reducing the Cobb angle and pain in the participants in their study. Yang, Lee, & Lee (2015) also conducted a study with the objective of determining the effects of stretching, the Schroth method, and muscle strengthening exercises in one adult with IS. The results indicated that the application of these methods led to a reduction in the Cobb angle (from 20.51° to 16.35°), and a reduction in pain in the lumbar region of the spine.

Regarding height, the applied exercise program contributed to improving height in all participants by 1.40±0.66 (mean±SD) cm, indicating an improved clinical presentation for participants with IS, in the sense that height increase is an indirect indicator that there had been a correction of the scoliotic curve. Consequently, based on observing children on the frontal and sagittal planes, we also observed improved posture, improved position of the body's center of mass, as well as an aesthetic enhancement of the relation between the left and right sides of the body. Kuru et al. (2015) used waist asymmetry instead of height as a similar parameter. The results of that study demonstrated that a decrease in the asymmetry of the convex side of the body had occurred in relation to its concave counterpart, measured via waist asymmetry. Schreiber et al. (2016) found positive effects of a six-month application of the Schroth method on a significant reduction of the curvature on the frontal plane, as measured by the Cobb angle. Another study, conducted by Orban & Horvat (2014), demonstrated the positive effects of an intensive one-year individual program using the Schroth method on the progression of the curve in patients with adolescent IS, and a Cobb angle greater than 45°. In the study conducted, the Cobb angle was measured prior to the commencement of the Schroth method treatment, but not at the end. For this reason, it is not possible to compare the results directly with studies where a change in the values of the Cobb angle had occurred, and with studies where the change in Cobb angle values was one of the major indicators of the efficiency of the treatment provided. However, in view of the positive change in height, whereby there was an increase in height in all participants at the final testing compared with the initial one, it can be assumed, albeit indirectly, that a reduction of the Cobb angle had also occurred. Thus, it can be argued, albeit only in an indirect way, that the study conducted identified positive effects of the Schroth method on reducing the Cobb angle in the participant. One objective flaw of this study is the absence of a control group. The reason for this was the specific character of the sample of participants, and the camp itself, lasting for ten days only, and allowing no possibility of organizing a control group as well.

CONCLUSIONS

The study conducted resulted in a positive effect on improving motor functionality, that is, enhanced flexibility and isometric endurance of the lumbar extensors of the spine. Furthermore, the study has demonstrated that, although we did not measure the angulation of the Cobb angle at the final measurement, an increase in height had occurred, which is an indirect indication that the applied program of intensive Schroth treatment had been efficient in correcting AIS in the sense of improving posture in the frontal and sagittal planes.

In view of the above, the practical contribution of this study is reflected in its practical applicability with children with adolescent IS, successfully contributing to an overall improvement in the above motor functional characteristics.

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EFEKTI SCHROTH METODE KOD DECE SA IDIOPATSKOM SKOLIOZOM

Skolioza je multifaktorijalna trodimenzionalna (3D) kičmena deformacija koja uvek uključuje elementarne deformacije u tri ravni: bočna krivina u frontalnoj, gubljenje prirodnih fizioloških krivina u sagitalnoj ravni i u većini slučajeva dolazi do povećanja lordoze u lumbosakralnom zglobu (formiranje hiperlordoze) i (veoma karakteristična) vertebralna aksijalna rotacija u horizontalnoj ravni. Jedna od najboljih metoda u korekciji skolioza je Schroth metoda. S tim u vezi cilj ovog istraživanja bio je da se utvrde efekti Schroth metode na korekciju funkcionalno motoričkog statusa kod dece sa adolescentnom idiopatskom skoliozom (AIS). Uzorak ispitanika činilo je 20 dece prosečne starosti od 14.5 godina koji su učestvovali na Schroth kampu u trajanju od 10 dana. Za procenu efekta Schroth metode korišćeni su merni instrumenti: Sorensov test, i Sit and reach test, kao i procena telesne visine. Ostvera su statistički značajna poboljšanja u rezultatima sva tri testa, Sorensov test, 45.6±19.29 s, Sit and reach test 4.05±2.25 cm i telesna visina 1.4±0.66 cm. Na osnovu

dobijenih rezultata može se zaključiti da je sprovedeni program vežbanja Schroth metodom ostvario pozitivan uticaj na poboljšanje motoričke funkcionalnosti, odnosno na poboljšanje fleksibilnosti i izometrijske izdržljivosti lumbalnih ekstenzora kičmenog stuba. Takođe, ostvareno je i povećanje telesne visine što ukazuje na pozitivnu promenu u smislu funkcionalnosti i simetričnosti leve i desne strane tela u smislu poboljšanja držanje tela u frontalnoj i sagitalnoj ravni.

Ključne reči: *fleksibilnost, mišićna izdržljivost, lumbalni ekstenzori*