

Rehabilitation Treatment Protocol in Scoliosis

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Abstract

Introduction: Scoliosis is a growing health problem in our population, which affects both children and adults. Surgery is the last resort, as it is a very invasive intervention. It is used in cases in which there is a progression of the curve, which reaches an angular value greater than 45° or 50° and the aesthetics are considerably deformed. For this reason, it is very important to apply physiotherapy from the beginning of the pathology, to avoid, as far as possible, a progression of scoliosis.

Objective: To establish the guide for the pre and post-operative rehabilitation treatment that will be applied to patients with scoliosis.

Methods: An electronic and library search of national and foreign medical journals indexed in Scielo, Imbiomed, Pubmed, Web of Science, Evidence-Based Physiotherapy (PEDro) that had been published for less than 5 years was carried out. The search strategy was developed in the period from July to September 2021.

Conclusion: The application of a rehabilitation protocol for patients in the pre and post-operative period of scoliosis contributes to the improvement of the prognosis and quality of life of these patients. The best results are achieved when there is a close relationship in the patient-physiotherapist binomial, following the doctor's instructions, that is, individualized treatment.

Keywords: Scoliosis; Rehabilitation; Pre and Post-Surgical Care; Physical Therapy Modalities; Applied Kinesiology; Exercise Therapy

Introduction

Scoliosis is defined as a three-dimensional deformity of the spine, where the frontal plane exceeds ten degrees and the lateral displacement of the vertebral body crosses the midline and is regularly accompanied by some degree of rotation, it is the most aggressive and deforming that affects the spine [1,2].

This deformity of the spinal column is a complex and dynamic process and occurs both in the sagittal and frontal planes, mainly in the thoraco-lumbar segments [2].

The classification of scoliosis is used to facilitate the objective assessment of the disease, according to the characteristics of the patient. There are different types of classification:

- Depending on the age of appearance of the deformity, it can be infantile (less than 3 years), juvenile (4 to 10 years) and adolescent (more than 10 years) scoliosis.
- Depending on the Cobb angle measured in the frontal radiograph, it can be mild scoliosis (Cobb angle less than 20°), moderate scoliosis (between 25 and 50°), severe (more than 50°).
- According to the topographic level of the lesion in the frontal plane, 4 main types of scoliosis are distinguished: thoracic, lumbar, thoracic-lumbar and S-shaped.
- According to the topographic level and the number of curves.

Depending on the etiology of scoliosis, the following are distinguished:

- Unstructured or functional scoliosis: it is an alteration in the alignment of the non-three-dimensional coronal plane, it is characterized by being flexible, disappearing when performing lateral inclinations of the trunk, it is not progressive and does not exhibit bone deformity.
- Structured scoliosis: it is characterized by the rotation and wedging of the vertebrae on the side of the concavity and the opening of the disc space towards the convexity [3-6].

The operation is the only procedure that has proven to be able to correct scoliosis, it is used in cases in which there is a progression of the curve, which reaches an angular value greater than 45° or 50° and the aesthetics are considerably deformed (that is, not only stop the progression of the curve, but reduce the curve or keep the spine straight) [7-11].

The application of physiotherapy from the beginning of the pathology, to avoid as far as possible, a progression of scoliosis, is essential in conjunction with postural education, the use of orthoses and surgery [12].

Objective of the Study

The objective of this research is to establish the application of a guide for pre and post-operative rehabilitative treatment aimed at patients with scoliosis at the secondary level of health.

Methods

An electronic search and in libraries of national and foreign medical journals indexed in Scielo, Imbiomed, Pubmed, Web of Science, Evidence-Based Physiotherapy (PEDro) that had been published for less than 5 years was carried out. The search strategy was developed in the period of May and August 2021. For the search, the following keywords were used: scoliosis, rehabilitation, pre and post-surgical care, physical therapy modalities, applied kinesiology, exercise therapy.

Developing

Protocol users

- Specialist physicians: Physical medicine and rehabilitation, orthopedic, internal medicine, pediatrician.
- Consultant physicians: Cardiologists, pulmonologist.
- Technician or graduate in physical medicine and rehabilitation.

- Nursing graduates.

Universe

Hospitalized patients in the Orthopedic service room with a diagnosis of scoliosis.

Origin of patients

The orthopedic and physiatrist, in a multidisciplinary team, will determine and select the patients with a diagnosis of scoliosis admitted to the orthopedic ward of the International Orthopedic Scientific Complex “Frank País”, in the spine service, with criteria of the pre and post rehabilitation program. postoperative.

Inclusion criteria

Patients with a clinical and radiological diagnosis of scoliosis.

Exclusion criteria

Patients with multiple pathologies in other levels of the spine.

Resources to use

Human resources

- Specialist in Orthopedics - Traumatology.
- Medical Specialist in Physical Medicine and Rehabilitation.
- Technicians and Graduates in Physical Therapy and Rehabilitation.
- Nursing graduates.

Material resources

- Stretcher or treatment bed.
- Chair.
- Adult parallel bars.
- Analgesic and/or electromotive current generating equipment.
- Rollers.
- Pillow.
- Therapeutic balls.
- Trellis.

- Scoliometer.
- Tallimeter.

Consultation and evaluation

At the beginning of the rehabilitation process, the patient should undergo a physiotherapeutic evaluation. A complete evaluation consists of an anamnesis with the data, the medical history, the physical examination and the evaluation of the functional capacity of the patient.

To measure the functional capacity of the patient, the Oswestry functional assessment test is performed. You can also apply different questionnaires: SF-36, CAVIDRA or SRS-22 (specific for scoliosis) [13].

Procedures

General standard precautions:

1. Hand washing before and after receiving the patient with hydroalcoholic solution or 0.1% hypochlorite.
2. Correct placement and removal of the personal protective equipment (PPE) indicated for each scenario detailed in this document, following the safety recommendations by the department of hygiene and epidemiology.
3. Maintain a safety distance of 2 meters whenever possible.
4. Minimize exposure times, as well as the number of people who are present in the work room.
5. Correct hygiene with 0.5% hydroalcoholic or hypochlorite solution in the workplace, as well as the equipment used after each patient and at the end of the day.
6. Gloves will be removed, if any, and hands will be washed with 1% hydroalcoholic or hypochlorite solution before and after performing any evaluation and rehabilitation activity with the equipment used in the high-tech laboratory, physical therapy and occupational therapy [14].

In the corrective exercises for scoliosis it is necessary to take into account:

1. It should not be corrected without strengthening or strengthening without correcting.
2. Towards the concave side, an Eccentric Isotonic muscle work will be performed in the corrective exercises.
3. Towards the convex side, an Isotonic Concentric muscle work will be performed in the corrective exercises.
4. Corrective exercises should be performed on inspiration, since the muscles that work on expiration increase the physiological curvatures of the spine and these in turn tend to increase the scoliotic curvatures.
5. In corrective exercises, extension exercises tend to increase the curves of scoliosis instead of reducing them.

Objectives of the exercises:

- Improve respiratory capacity.
- Strengthen paravertebral and abdominal muscles.
- Correct deformity.

Golden rule

- Observation: Implies that the patient will be monitored by means of an examination and X-rays throughout successive visits with the specialist every four to twelve months.
- Corsets: A rigid plastic scoliosis brace (also called a brace) that fits around the torso and hips and applies counter pressure to the curve.
 - Milwaukee corset: Curves with vertebra limit superior to D8, in the dorsolumbar curves and in the doubles.
 - Boston: Low dorsal and lumbar scoliosis in early ages with useful growth potential (Risser 3). In simple or double curves between 20° and 40°.
 - CRC: Idiopathic scoliosis, curved with the upper limit vertebra at the upper dorsal level, it is more aesthetic.
- Surgery.

Treatment of functional scoliosis (non-structural scoliosis)

Training

The aim is to select a starting position that makes the curves disappear. Once this is achieved, the objective will be to prevent the deviation from reappearing, through a progressive re-education of the automatic reflex mechanisms, which maintain the alignment of the spine in the activities of daily life.

The exercises are of 2 types in this re-education program:

- Segment (mobilize 1 or more joints): They will be symmetrical.
- General (or ambulatory): Movements of the whole body.

Segmental exercises

Trunk parallel to the ground in: supine, prone, horizontal quadruped. In each of these positions and for each exercise there are 4 steps: initial position (execution n seconds), final position physiological rest (select it), isotonic exercises (n: seconds) relaxation and isometric exercises (breathing).

These exercises will be selected in such a way that they contract in a tonic and statically coordinated way the dorsal extensors; This allows to awaken the kinesthetic sensations and the muscular sense awareness, the position that the different segments of your body occupy in space (at rest and during exercise) and allows you to regulate your movements.

Example: Contact surface techniques, previously there must be a straight line drawn on the floor:

- The patient in the supine position will place: Head, neck, trunk on this straight line, the lower limbs and upper limbs symmetrical with respect to the rest of the body. This will be done with your eyes open, then with your eyes closed. The therapist will correct (with verbal instructions, touching the patient or assisting with passive movements) any misalignment.
- Once the proper position is achieved, the patient is guided to relax, without making any additional movement that would make him lose his position (regulation of tonic functions).

In non-structural or functional scoliosis, the flexibility of the spine allows the paravertebral muscles to work in dynamic movements.

Examples of exercises:

1. For the cervical extensors (prone position): Head, neck in a straight line, forehead resting on the back of the hands (resting one hand on the other), trunk and lower extremities aligned, raise the head, removing the forehead from the support, without extending the neck backwards: hold the second position.
2. Exercises for dorsal extensors: Supine position: head, neck, trunk and lower extremities in a straight line, with the feet in plantar flexion, oblique arms towards the feet, palms facing the ceiling with the thumbs outwards: arch your back, touching the ground with your neck and sacrum; hold arched position, in seconds.
3. Exercises for longitudinal stretching of the spine: In supine position, arms above the head and parallel to each other, head, neck, trunk and lower extremities in a straight line, feet in dorsal extension: simultaneously both arms will be pushed on the head, at as long as the feet are dorsiflexed, hold the position, in seconds.
4. **Exercises for lumbar extensors**
 - a. Patient in prone position, forehead supported by both hands, lift slowly and alternately each lower limb, maintaining stiffness in extension; Progress will vary according to height and number of repetitions.
 - b. The same starting position, lift both lower extremities together in rigid extension to a certain height.
 - c. The same previous exercise, but alternating one and the other lower limb in rigid extension (simulate the swimming movement).
5. Exercises for dorsal extensors, combined with cervical and lumbar extensors: in the prone position, extension of the dorsal column without extension of the neck, initially; in a second time, place the oblique arms downwards; third time, simultaneously lift upper and lower extremities in rigid extension (in seconds).
6. There are different positions of the arms for progressive exercises of the dorsal extensors: oblique arms (a), elbows flexed (b), hands on shoulders (c), arms at a right angle (d), arms at the height of the shoulders (e), hands on the back of the neck (f), oblique arms above the head (g), vertical and parallel arms (h)
7. Associate the movements of the arms, movements of the legs: (a) initial position. (b) First exercise: raising the arms obliquely above the head and off the ground and the legs extended in extension also off the ground. (c) The same exercise, but lowering the arms obliquely (d) The same exercise, but alternating the extension movements asymmetrically: cross stretch (example: right

arm left leg and vice versa).

8. There are more complicated exercises for functional scoliosis: dry swimming:
 - a. Movement of the arms in 3 times, starting from the starting position (a) and ending in the final position (d).
 - b. Dry swimming: Foot movement.
 - c. Dry swimming: it integrates the simultaneous movements of arms and legs.

For all of these exercises in the prone position, a cushion will be placed under the abdomen to correct the lumbar lordosis.

9. There are exercises or games: prone or supine, pushing balls with your hands or feet, over an obstacle of variable height in a progressive way.

So far the simple and complex segmental exercises, but performed in situ and in decubitus, always starting from initial corrective positions.

10. There is a third position (horizontal quadruped) described by R. Klapp: position that reduces non-structural scoliosis: arms and thighs parallel to each other and perpendicular to the ground and from this position execute lordotic and kyphotic quadruped.
11. An exercise to exercise the back muscles cross balance.
12. Exercise that increases the strength of the extensor muscles of the spine: with the feet hooked on the lower bar of the trellises, raise the hands off the ground with the arms back and oblique, and the trunk parallel to the ground, you can also finish them with bent elbows.
13. From the previous position, perform lateral push-ups of the trunk to the right and left, keeping the neck, shoulders and back in the same horizontal plane.
14. Starting from the horizontal quadruped, move to a low quadruped, flexing the elbows, pressing the chest to the ground.
15. Starting the new exercise in a horizontal quadruped, move to a kneeling quadruped. In these last 2 final positions, low quadruped and kneeling quadruped, you can perform right / left lateral push-ups.

General or outpatient exercises for nonstructural scoliosis

They are active exercises, accompanied by movements of the whole body.

Ambulatory exercises: Sports movements, games, dances, rhythmic exercises.

Treatment of structural scoliosis

In this case, the goal of cine-therapy is

1. Prevent progression and correct scoliosis.
2. Complement the treatment with a corset.
3. Prevent postoperative complications.

Structural scoliosis exercises, regardless of the method in question, have the following treatment pillars:

1. Stretches: Of the entire spine, the upper part or the lower part of it; they can be active or passive, symmetrical, but fundamentally asymmetric.
2. Postural exercises: In decubitus position, sitting, standing and while walking: vasculature of the pelvis.
3. Flexibilization exercises: Flexibilization of the joints: coxofemoral, flexibilization or stretching of the hamstrings, flexibilization of the lumbar spine, flexibilize the pectoral muscles, etc.
4. Lateral extension exercises in the opposite direction to the deformity.
5. Derotation exercises.
6. Muscle-building or strengthening exercises, both for the paravertebral (cervical, dorsal, lumbar) and abdominal muscles.
7. Breathing exercises: diaphragmatic breathing, upper costal, lower costal, etc.

Training

1. Active stretching, vertebral self-extension: the patient, with his back to the wall, without separating the back of it, will rise on points trying to push with his head a mobile arm that has been placed at that level and will hold for n seconds, in this position with rest and repetition.
2. Postural exercises: supine pelvic tilt with knees bent and extended, placing the lumbar region on the floor by contracting the abdominal muscles, without raising the buttocks. In this position, retract the chin by stretching the neck, as if the head were separated from the shoulders.

Walking, sitting, standing with pelvic tilt or vasculature, chin retraction and shoulders back.

3. Flexibility exercises:
 - a. Coxofemoral joints: supine, buttocks on the edge of the table, one leg folded over the abdomen, the other lowered down. The physiotherapist fixes the foot of the folded leg with his hip and fixes the knee with his hand, fixing the pelvis with the other hand placed above the knee of the hanging leg and exerts pressure downward progressively (necessary in fixed anteversion of the pelvis, limitation of hip extension).
 - b. Flexibilization or stretching of the hamstrings: supine. The Physiotherapist places the patient's heel on his shoulder, placing the hands above the knee to keep the leg extended and pushing the leg towards the trunk. The other leg is kept extended by the therapist's knee.
 - c. Flexibility of the lumbar spine in flexion, "Mohammedan prayer": Kneeling, sitting on the heels. Knees apart, drop body forward. Arms outstretched, inhaling, trying to touch the ground as much as possible, without detaching the buttocks from the heels.
 - d. Pectoral stretch: Elbows bent 90° and placed at shoulder height. Stand in this position in front of 2 walls that form an

angle of 90°, separate the feet 20 or 30 cm, the body in a straight line, support a forearm on each wall and push the trunk forward in the direction of the vertex of the angle formed by the walls. This movement should be slow and gentle.

4. Lateral extensions: Supine, flexed left knee, foot resting on the ground (folded on the belly). Right leg extended, left hand on the shoulder, right hand exerting lateral pressure on the thorax, at the level of the scoliotic arrow extend the left arm and stretch the left arm and leg, inhaling (in right dorsal and left lumbar scoliosis).
5. Derotation exercises: On all fours on the knees (apart) throw the left arm laterally upwards. Hand in supination, the right hand resting on the floor, the physiotherapist leans on the right gibosity and forces the left arm to twist by traction. Derotation is located at the level where the pressure is applied and with the search at this same level, an extension of the anteroposterior spine (useful in dorsal scoliosis, lumbar dorsum or lumbar: right).
6. Bodybuilding exercises: strengthening the paravertebral, general and abdominal muscles:
 - a. Asymmetric dorsal bodybuilding: on all fours on the knees, left arm extended horizontally. Hand held to the trellis, raised right leg straight and back stretch (used in left thoracolumbar scoliosis).
 - b. Abdominal bodybuilding: in supine position, elbows bent, arms relaxed resting on the floor, pelvis in retroversion, knees bent, feet on the floor, raising a bent leg, extension of this to the vertical, new flexion and rest of the foot on the floor.
7. Respiratory exercises:
 - a. Strengthening exercises of the diaphragm and the transverse:
 - Supine position, in maximal inspiratory apnea, cleave and forcefully remove the abdomen.
 - Dorsal position: after deep inspiration, exhalation effort, closed glottis or against resistance.
 - Progressive dosed expiration in the spirometer.
 - b. Exercises for thoracic expansion: Supine. The physiotherapist compresses the base of the last ribs with the hands placed on the thorax. The patient is asked to stretch his arms in the extension of the trunk, level with the neck, taking a deep breath (hourglass chest).
8. Balance exercises:
 - a. Asymmetric balance: Standing: Elevation of the left knee or abduction of this leg with stretching of the right arm upwards (left thoracolumbar scoliosis).
 - b. Symmetrical balance: Walking with a book on your head or holding it without to fall, in static standing.
9. Exercises inside the cast or orthopedic corset. Some examples
 - In standing, take off the mental and occipital supports by self-stretching with breathing (it will make slight lateral inflections of the head).
 - Dorsal position: Alternate stretching of both lower limbs, stretching them to the maximum (forced lateroversion). This

exercise prevents compression of the femoral cutaneous nerve.

- Prone position: Arms in a U or longitudinally above the head, raise the elbows or arms, respectively, upwards.
- Prone position: Pushing, inspiring. Therapist's hand placed on the upper chest depression.
- Prone or sitting position: Passive flexibilization by pressure on the humps on inspiration.
- Sitting on the bench: Press your arms forward, rolling your shoulders and lowering your head. Deep inspiration in this position. Breathe out and relax.
- In the quadruped position, the previous exercise is repeated.
- Dorsal position: with pelvic inclination and bent knees, keep the lumbar region against the cast, without raising the buttocks.
- The same exercise with extended knees.
- In prone position: Support of the hands, raise the trunk fully extending the elbows, head, shoulders, knees, in a straight line during the execution.
- Prone: Place a cushion under the abdomen and a rolled towel under the forehead. Arms extended to the sides of the body with the palms down, vascular the pelvis, bring the scapulae closer and bring the shoulders back.
- Prone: Arms at the sides of the body. Elevate the head and arms, approximately 25 millimeters.
- Prone: Keep the chin retracted and stretch the neck as if the head were separated from the shoulders. Eyes directed to the ground.

Postoperative treatment of scoliosis

Regardless of the surgical technique used, the following day after surgery are indicated: respiratory exercises, en bloc decubitus changes, isometric exercises for the quadriceps and glutes, gentle free exercises without causing pain in the upper and lower limbs, active exercises that strengthen the quadriceps:

- You will not orient yourself to sit until the surgeon guides you; This indication can take weeks or months.
- Standing is currently early, in the course of the first two weeks it is incorporated to the bipedal position and returns to decubitus: always en bloc.

Exercises in the standing position are not performed until there is consolidation of the fusion (radiological). Paravertebral stretching and strengthening exercises, according to the surgeon's criteria.

There are several methods of physiotherapeutic treatment of scoliosis such as:

- Schrot method: The principles are deflection, distortion and obtaining a physiological sagittal pattern.
- Klapp's crawling exercises: Its purpose, from an initial position, is unloaded, mobilized and thus corrected by maximum muscle tension.

- Niederhoffer method: Strengthening the trunk (dorsal and ventral chain), for the elaboration of a muscular corset.
- Burger Wagner: Combination of symmetrical and asymmetric active exercises.
- Mézières: Elongation of the spine.
- The method of fixation, derotation and elongation (FED): It is a three-dimensional elongation system, which uses an apparatus with a mechanical arm that performs a maximum push (intermittent or continuous) of the column, for a certain time. The pressure is exerted on the point of greatest inclination and rotation of the curve, exerting the force in the opposite direction to the deformity produced by the scoliotic curve.
- Global postural rehabilitation or RPG: It is based on the stretching of the gravitational muscles and the toning of the dynamic muscles, avoiding compensations.
- Among others [1,3].

All specific physiotherapy treatment methods for scoliosis should influence the angle of curvature, improvement of cardiorespiratory parameters, reduction or suppression of pain and improvement in aesthetics and quality of life. They are based on three principles: facilitating proper postural perception by enhancing the muscles that maintain correction, making concave segments more flexible (with concentric isotonic work) and stretching shortened muscles (eccentric isotonic work) [15-19].

Evaluation and control of the protocol

The evaluation and correction of the protocol will be carried out every 2.5 years.

Conclusions

The application of a rehabilitation protocol for patients in the pre and postoperative period of scoliosis, contributes to the improvement of the prognosis and quality of life of these patients. The best results are achieved when there is a close relationship in the patient-physiotherapist binomial, following the doctor's instructions, that is, individualized treatment.

Conflict of Interests

The authors declare that they have no conflict of interest.

Bibliography

1. Alonso González N., *et al.* "Current focus on the rehabilitation of scoliosis". *Digital Anatomy* 2.3 (2019): 6-17.
2. Jerez Labrada Jorge Alberto., *et al.* "Hybrid system for the surgical treatment of adolescent idiopathic scoliosis. Cienfuegos, 2016-2017 (Preliminary study)". *Medisur, Cienfuegos* 18.6 (2020): 1172-1178.
3. Santocildes Salgado L. "Bibliographic review on the effectiveness of physiotherapy in patients with scoliosis" (2021).
4. *Scoliosis - Types, Causes, Symptoms and Treatment* (2017).
5. Ubillus-Carrasco GE and Sánchez-Vélez A. "Scoliosis: A frequent problem, but underdiagnosed". *Rev. Medical Body. HNAAA* 11.3 (2018).
6. "Argentine Society of Pediatrics Subcommittees, Committees and Working Groups Consensus on adolescent idiopathic scoliosis". *Archivos Argentinos de Pediatría* 114.6 (2016): 585-594.

7. Rushton PRP and Grevitt MP. "What Is the Effect of Surgery on the Quality of Life of the Adolescent With Adolescent Idiopathic Scoliosis? A Review and Statistical Analysis of the Literature". *Spine* 38 (2013): 786-794.
8. Lorente A., et al. "Cariorespiratory function does not improve 2 years after posterior surgical correction of adolescent idiopathic scoliosis". *Spine* 42.18 (2017): 1391-1397.
9. Diarbakerli E., et al. "Adults With Idiopathic Scoliosis Diagnosed at Youth Experience Similar Physical Activity and Fracture Rate as Controls". *Spine* 42.7 (2017): E404-E410.
10. Hu Z., et al. "A neglected point in surgical treatment of adolescent idiopathic scoliosis variations in the number of vertebrae". *Medicine* 95.34 (2016): 7.
11. Diarbakerli E., et al. "Adults With Idiopathic Scoliosis Diagnosed at Youth Experience Similar Physical Activity and Fracture Rate as Controls". *Spine* 42.7 (2017): E404-E410.
12. Rustagi T., et al. "Surgical treatment of early-onset idiopathic scoliosis in the United States: a trend analysis of 15 years (1997-2012)". *The Spine Journal* 19.2 (2019): 314-320.
13. Liu Z., et al. "The Superiority of Intraoperative O-arm Navigation-assisted Surgery in Instrumenting Extremely Small Thoracic Pedicles of Adolescent Idiopathic Scoliosis: A Case-Control Study". *Medicine* 95.18 (2016): e3581.
14. Milanés L. "Covid-19: Protocol and biosafety in Cuba (+ Infographics)" (2020).
15. Leal JS., et al. "Accuracy of photogrammetry for detecting adolescent idiopathic scoliosis progression". *The Spine Journal* 19.2 (2019): 321-329.
16. Andrusiewicz M., et al. "IMP2 polymorphisms association with curve initiation and progression of thoracic idiopathic scoliosis in the Caucasian females". *Journal of Orthopaedic Research* (2019).
17. Chen C., et al. "LncRNA-SULT1C2A regulates Foxo4 in congenital scoliosis by targeting rno-miR-466c-5p through PI3K-ATK signaling". *Journal of Cellular and Molecular Medicine* (2019).
18. Xu L., et al. "Genetic Variant of PAX1 Gene Is Functionally Associated with Adolescent Idiopathic Scoliosis in the Chinese Population". *Spine* 43.7 (2018): 492-496.
19. Einarsdottir E., et al. "CELSR2 is a candidate susceptibility gene in idiopathic scoliosis". *PLoS One* 12.12 (2017): e0189591.

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