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EVIDENCE BASED POSTOPERATIVE PHYSIOTHERAPY MANAGEMENT OF ADOLESCENT IDIOPATHIC SCOLIOSIS - A LITERATURE REVIEW

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The purpose of this thesis was to gather evidence-based and up-to-date studies about Adolescent Idiopathic Scoliosis (AIS) and its' post-operative physiotherapy management. The thesis was made for Satakunta Central Hospital (Satakunnan keskussairaala). The need for such topic came from the physiotherapists working at the paediatric outpatient clinic. They wanted to have concrete updated information of post-operative physiotherapy management for scoliosis surgery patients.

The theoretical part of the thesis consists of basic anatomy of the spine, different forms of scoliosis and the deficits effects on the human and both the conservative and surgical management of scoliosis.

The data collection was done in the form of a literature review. The search process was performed using Pubmed, EBSCO and ScienceDirect as databases. The literature review was conducted in autumn 2015. Eight studies remained after applying in- and exclusion criteria.

The results varied greatly and showed that there are several areas in which physiotherapists could offer their professional skills: restoring patients' dynamic breathing and sensorimotor postural control, instructing a preoperative weight management program, inquiring what could be the reasons behind the reduced time spent in sports and the late full-time return to school.

CONTENTS

1 INTRODUCTION

Adolescent Idiopathic scoliosis is a three-dimensional deformity of the spine. In Finland 0,2% of the population have scoliosis, which requires medical attention. (Nissinen, et al. … 1993, 1.) There are approximately 250 new scoliosis cases discovered every year in Finland from which 80% are idiopathic scoliosis, one of the subgroups of structural scoliosis (Pihlajamäki & Ruuska 2010, 1). Adolescent Idiopathic scoliosis, which is the largest type of idiopathic scoliosis and which requires medical treatment is ten times more common in girls than in boys. (Helenius 2015, 1.)

The treatment of scoliosis is either conservative or operative depending on the magnitude of the curve. Both conservative and surgical treatment methods of scoliosis have been well studied. Conservative management consists of screening of scoliosis, follow-up and orthopaedic bracing. (Helenius 2013, 1.) When conservative treatment measures fail, non-conservative management, a spinal fusion operation is performed. (Helenius 2009, 1169.) Scoliosis surgery is the only treatment method for scoliosis, which can correct the already curved spine (Helenius 2009, 1169; Ryöppy 1997, 120). Great results have been accomplished with scoliosis surgeries (Pihlajamäki & Ruuska 2010, 16).

What has not yet been fully studied is the postoperative management of Adolescent Idiopathic Scoliosis. This thesis aims to find out what could be the areas in which physiotherapy management would be needed. Currently, the only physiotherapy management that is offered to the patients is during the first week after the surgery in a hospital ward. After the patients return from hospital to home, the only management they get is the orthopaedist's controls. (Helenius & Pajulo 2015, 1785.)

The purpose of this thesis is to gather evidence-based and up-to-date researches about AIS and its' post-operative physiotherapy management. The client of the thesis is Satakunta Central Hospital (Satakunnan Keskussairaala). The need for such topic came from the physiotherapists working at the paediatric outpatient clinic. They wanted to have concrete updated information of post-operative physiotherapy management for scoliosis surgery patients. This literature review aims to give helpful in-

formation, which would benefit the physiotherapists in their clinical work. (Lempinen 2015.)

2 ANATOMY OF THE SPINE

Tortora and Derrickson define anatomy as “the science of body structures and the relationships among them” (Tortora & Derrickson 2011, 2). This chapter will focus on regional anatomy, referring to a certain body part, which in this thesis indicates to the spine of a human. Knowledge of a healthy spine and its’ structure is needed to later define a spine with a defect, such as scoliosis. (Tortora & Derrickson 2011, 2.)

2.1 Anatomy and Physiology of the Spine

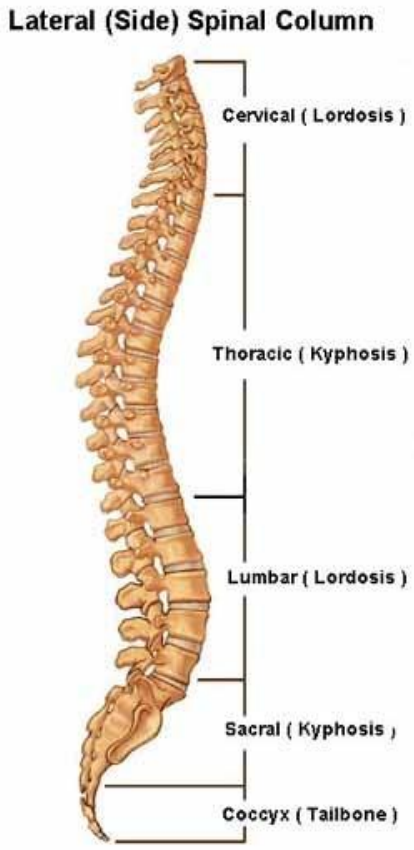
The spine or vertebral column is shaped of twenty-four individual bones called vertebrae (singular: vertebra). It is divided into three regions, which are the following: cervical (neck), thoracic (chest) and lumbar (low back). Cervical spine is shaped of 7 individual vertebras while thoracic spine of 12 and lumbar spine of 5 vertebras. There are typically four curves in the spine: cervical lordosis, thoracic kyphosis, lumbar lordosis and sacral kyphosis (picture 1). While cervical and lumbar curves are convex, oppositely thoracic and sacral curves are concave relative to the front of the body. This specific curving of the spine enables the spine to be flexible, mobile and a help in maintaining the balance of the body. Yet it functions as a supporting and strong structure of the body. These curves are most visible observed from the lateral aspect. (Tortora & Derrickson 2011, 233.)

Vertebral columns lowest regions are sacrum, which is formed of 5 fused vertebras and coccyx, the tailbone fused of four vertebras. Neither of them are mobile parts of the spine and thus will not be discussed thoroughly in this chapter. Other bones that complete the skeleton of the trunk of the body are the ribs and the sternum. A human spine is approximately 71 centimetres long in male adults and 61 centimetres long in female adults, covering two-fifths of the length of the body. In addition to being composed of bony structures, the vertebral column is formed of connective tissue. (Tortora & Derrickson 2011, 233.)

The purpose of the spine is to protect the spinal cord, function as a flexible rod and shock absorber, support the head and work as an attachment site for the ribs, pelvic

girdle and the many back and core muscles. Its' movements are flexion (forward bend), later flexion (side bend), extension (backward bend) and rotations. (Tortora & Derrickson 2011, 233.)

Different conditions and general progression of old age might disturb the spine's normal curves. The most common abnormalities of the spine are excessive kyphosis, lordosis and scoliosis, the latter will be discussed throughout the thesis. (Tortora & Derrickson 2011, 234.)



Picture 1. The anatomy of the spine, showing four natural curves and five regions of the spine. (Website of the Spine Universe 2015)

2.2 A Vertebra and an Intervertebral Disc

A typical vertebra consists of a vertebral body, vertebral arch and many processes (picture 2). The vertebrae differ in shape and size depending on which region they are located in (Agur & Dalley 2012, 292). The vertebral body is the thickest and

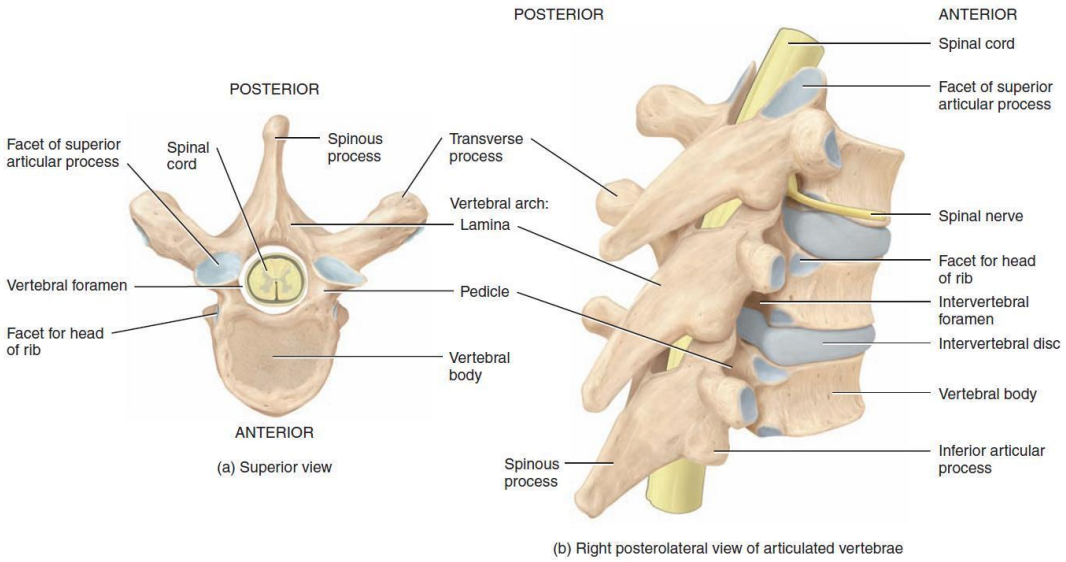
strongest part of a vertebra and is shaped as a disc. On the top and bottom of every vertebral body there are intervertebral discs attached to them, which is made possible by the rough surface of the vertebral body. The vertebral body is the weight-bearing part of the vertebra and is well suited for this purpose by being thick in shape. It is the most anterior part of the vertebra. (Tortora & Derrickson 2011, 235.)

The vertebral arch includes both pedicles and laminas. Pedicles are two processes, which protrude posteriorly from the vertebral body and are short and thick in shape. They unite to the flat layers, laminas and together form the vertebral arch. The vertebral body and the vertebral arch together shape a vertebral foramen, an empty space between them. When there are many vertebras stacked on top of each other, together they formulate vertebral canal or spinal canal, which enables the spinal cord to go through the vertebra and surround important structures. In addition to the spinal cord, blood vessels, spinal nerves, areolar connective tissue and adipose tissue go through the canal. (Tortora & Derrickson 2011, 235.)

There are altogether seven processes that protrude from the vertebral arch. Where a lamina and a pedicle are united a transverse process extends on both lateral sides. These are the most lateral parts of the vertebra. A spinous process, a single and the most prominent process, continues from where the laminae end. It is the most posterior part of the vertebra and often can be seen posteriorly in a human. Many muscles are attached to the transverse processes and the spinous processes. There are four more processes, which attach to the other vertebral processes superiorly and inferiorly: two superior articular processes and two inferior articular processes both known as facets. (Tortora & Derrickson 2011, 234.)

Intervertebral discs are soft, pulpy and elastic structures, which work as pads between the vertebrae. Its' main purpose is to absorb vertical shock and to enable movement by being flattened and broadened depending on the pressure it receives from other surrounding structures. The disc consists of fibrocartilage layer, the annulus fibrosus that covers a softer inner substance called nucleus pulposus. Because the discs contain a lot of fluid, typically, during the day the discs lose water from their cartilage affecting the height of the intervertebral disc. This is the reason why we are shorter after the strenuous day. During the night the discs get rehydrated affecting in

us so that we attain our full height again in the mornings. The discs are avascular meaning that they get their blood supply from surrounding structures. Exercising enables better blood flow to these structures, which increase both the nutrient and the blood flow also to the intervertebral discs. (Tortora & Derrickson 2011, 234.) Scoliosis causes pathological effects on these structures (Website of UW medicine, Department of Scoliosis).



Picture 2. A typical thoracic vertebra. (Principles of Anatomy and Physiology, 2011)

3 SCOLIOSIS

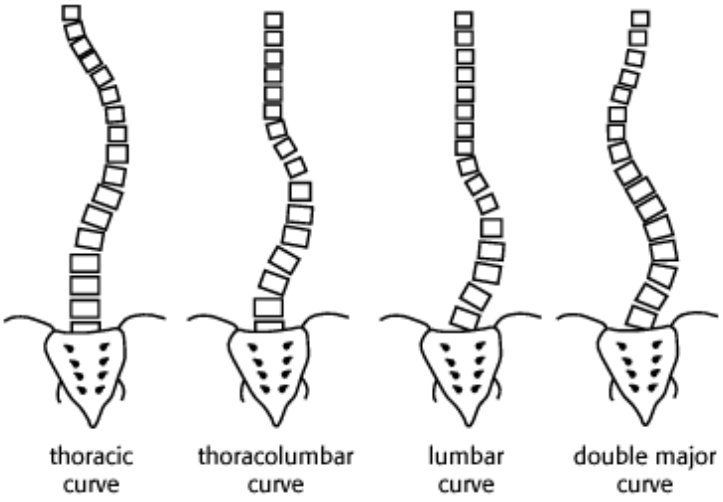
The natural curves of the spine are cervical lordosis, thoracic kyphosis and lumbar lordosis, which can be seen when observed from the side. The curves enhance the spine to be flexible and mobile. When there is scoliosis involved, the natural curves of the spine are imbalanced and the optimal flexibility is lost. (Ryöppy 1997, 119.)

Scoliosis is a condition in which the spine curves laterally and vertebral bodies rotate in addition causing a three-dimensional deformity in the thoracic or lumbar spine. A healthy spine looks straight when observing a human being from behind, but with scoliosis patient, the spine forms a ”C” or ”S” -shape depending on the amount of the

curves. In Cobb angle measurement the curve has to be over 10° to be defined as scoliosis. (Helenius 2009, 1168.)

Scoliosis can be also noticed with a bare eye as trunk asymmetry. Uneven horizontal level between the tips of the ears, shoulders, posterior angles of the scapulas, waist curves, posterior-anterior iliac crests and knees can suggest that a person has a scoliosis. In these cases further assessment needs to be done to determine the severity and type of the scoliosis. (Kerttula, Schlenzka & Tallroth 2004, 2298.)

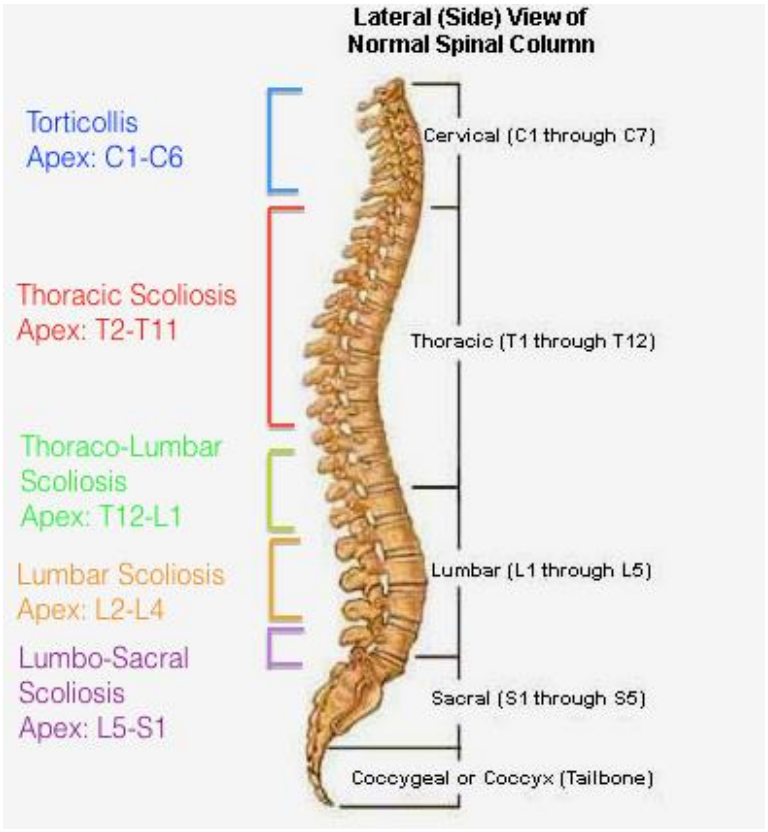
In scoliosis, there can be one or more curves: only one primary curve or a double curve, which consists of a primary curve and one or more secondary curves. The secondary curves try to compensate the more severe curve by turning to the opposite direction evening out the primary curve and thus balancing the spine (picture 3). Regardless of the scoliosis, the spine tries to find a balanced posture, aiming to keep the head in a fairly good position. (Pihlajamäki & Ruuska 2010, 4.)



Picture 3. Different types of scoliosis curves, demonstrating spines with both single curve and double curves. (Website of Broadway Chiropratctic and Wellness Center New York 2015)

Scoliosis is often classified based on the location of the primary curve where the apex is the most curved part of the spine. It is also the part, which is the furthest away from the midline of the spine (Pihlajamäki & Ruuska 2010, 2). In thoracic sco-

liosis the apex is between T2-T11, in thoraco-lumbar scoliosis between T12-L1, in lumbar scoliosis the apex is between L2-L4 and in lumbo-sacral scoliosis the apex is between L5-S1 (picture 4). The curvature in cervical spine is called torticollis rather than scoliosis. In torticollis, the apex of the curve is between the vertebras C1-C6. (Magee 2008, 478.)

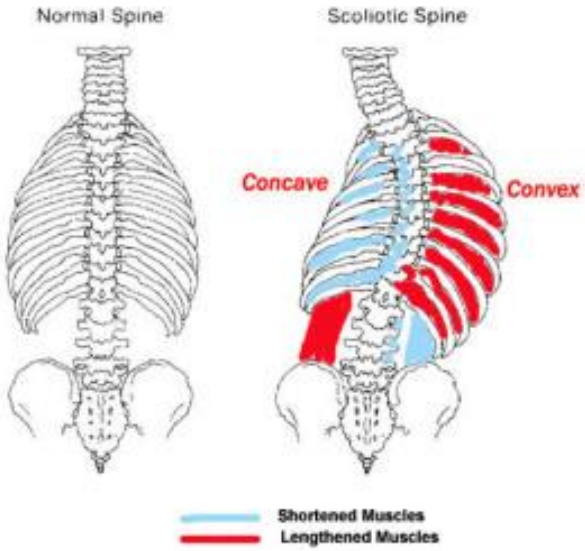


Picture 4. A demonstration of the classification of scoliosis based on the location of the apex of the curve. (Own files)

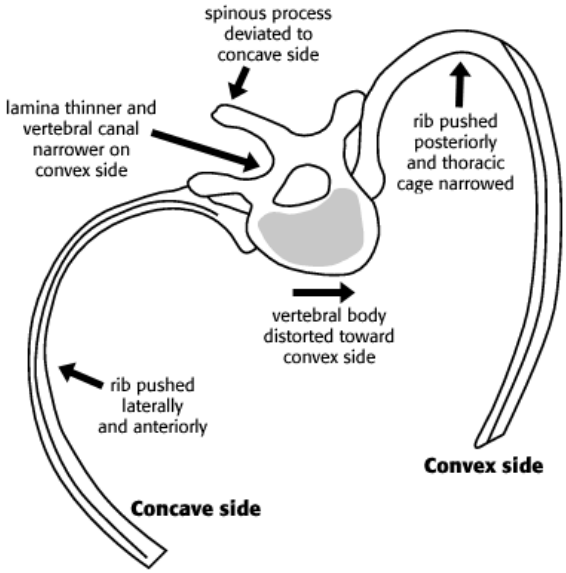
Scoliosis is most often symptomless. Only every fourth person suffering from scoliosis has back pain typically in the thoracic spine, between the scapulas or in the lumbar spine (Helenius 2015, 1). The occurrence of back pain in adult scoliosis patients is the same as with those who do not have scoliosis. Still, if a scoliosis patient has back pain, it is more difficult to treat it. (Hakkarainen 2007, 1.) One more rare symptom can be spondylolisthesis, a forward displacement of a vertebra. Scoliosis is divided into two main groups: structural scoliosis and non-structural or functional scoliosis. (Kerttula, Schlenzka & Tallroth 2004, 2298.)

3.1 Biomechanical Changes of the Spine In Scoliosis

The curve of the spine can be either convex (referring to the hump side) or concave (referring to the hollow side). In thoracic structural scoliosis the vertebral bodies rotate towards the side of the convexity (picture 5). From this effect the spinous processes of the vertebraes oppositely rotate to the concave side. This rotation of the spine causes the vertebral bodies to push the ribs posteriorly narrowing the ribcage on the convex side and causing a rib hump on the posterior side (picture 6). This cosmetically poor appearance and deformity is called razorback spine. This is characteristic for scoliosis patients and becomes more visible in a flexed position. On contrary the ribs on the concave side move anteriorly causing a hollow cave on the back and a widening on the ribcage. (Magee 2008, 478.)



Picture 5. Demonstration of the effects of concavity-convexity of the spine and the effect of it to the muscles. (Website of Chiropractic Specialty Centre 2015.)



Picture 6. Demonstration of the effects of scoliosis in thoracic spine and ribcage. (Website of Chiropractic Specialty Center 2015)

3.2 Structural Scoliosis

As the name structural scoliosis suggests, there is a permanent change in the structure of the bones, in this case vertebras, which formulate the spine. This means that the process can only be slowed done, not fully corrected even with a spinal correction surgery. Structural scoliosis is divided into subgroups according to how it has been formed: congenital, idiopathic and neuromuscular scoliosis. Approximately 70-90% of structural scoliosis are categorized as idiopathic. (Kerttula, Schlenzka & Tallroth 2004, 2298.)

3.2.1 Idiopathic Scoliosis

Idiopathic scoliosis is divided into Infantile, Juvenile and Adolescent idiopathic scoliosis (AIS) depending on the age of the onset of scoliosis, the latter being the most common scoliosis of all of the scoliosis subgroups. Idiopathic scoliosis is often first diagnosed in adolescents. (Crowther 1999, 139.) It is also found in infants and juveniles, but is far less common. The main focus of the thesis will be on AIS because it is most common of all the scoliosis subgroups. There are approximately 200 new AIS cases appearing every year in Finland. (Hakkarainen 2007,1.) There is no known

cause for Idiopathic scoliosis, thus the word ”idiopathic” translating to ”of unknown cause”. In idiopathic scoliosis the curve is normally a double curve shaped as an S-letter. (Kerttula, Schlenzka & Tallroth 2004, 2298.)

Infantile Idiopathic scoliosis (IIS) appears and is diagnosed before the third year of life (Kerttula, Schlenzka & Tallroth 2004, 2298). Typically there is only one primary curve, which is convex to the left (Adams & Hamblen 2001, 179). Infantile Idiopathic scoliosis is more common in the male population than in the female with the ratio of 3:2. Infantile Idiopathic scoliosis is the least common type of the idiopathic scoliosis. (Helenius & Parkkila 2008, 2541.) Infantile Idiopathic scoliosis can worsen rapidly in a few months. This is the reason why it is extremely essential for IIS patients to get the needed medical care, which most often is more than one scoliosis surgery or continuous orthopaedic plastering. The treatment has to slower down the scoliotic curving yet still secure the continuing growth of the spine, which makes it challenging (Helenius & Pajulo 2015, 1785.) Juvenile idiopathic scoliosis is diagnosed between the ages of four to nine years. (Kerttula, Schlenzka & Tallroth 2004, 2298).

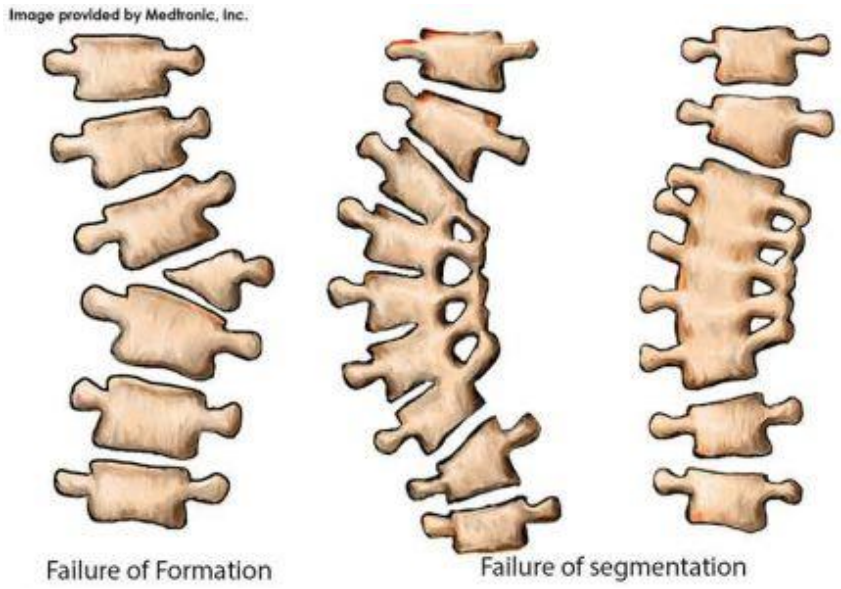
Adolescent idiopathic scoliosis is a three-dimensional deformity, which appears in the late childhood or the early adulthood, from the age of ten to the end of growth spurt. It is only known that AIS is connected to a hormonal development since it most commonly occurs during the age period when the child is having a growth spurt, commonly between the ages of 10 and 12 years. (Adams & Hamblen 2001, 180.) There is a progressive increase in the curvature until the cessation of the skeletal growth. As most of the other scoliosis subgroups, also AIS is not symptomatic. Adolescent Idiopathic scoliosis that requires medical attention and treatment is ten times more common in girls than in boys. (Helenius 2015, 1.) AIS in progresses more likely in girls than it does in boys (Pihlajamäki & Ruuska 2010, 5).

3.2.2 Congenital Scoliosis

Congenital scoliosis is caused by vertebral anomalies, which can be radiographically seen in a newborn baby. Although the anomalies are present already at birth, there

might not be a clear curvature in the spine until the adolescent years. The spine is typically sharply curved in congenital scoliosis. It is unusual that congenital scoliosis runs in families. (Weinstein 2001, 161.) Ten percent of the scoliosis cases are congenital (Kerttula, Schlenzka & Tallroth 2004, 2298).

The spine is anatomically completed during the first 6 weeks of intrauterine life, during this time the defect occurs due to an unknown reason. The defect can be either in the segmentation or in the formation of the vertebrae (picture 7). Also, congenital scoliosis patients typically suffer from other developmental disorders of important organs such as the heart. The most common treatment in congenital scoliosis is a surgical operation where the malformed vertebra is removed. (Pihlajamäki & Ruuska 2010, 3.)



Picture 7. Different defects of segmentation in congenital scoliosis. (Website of Virginia Spine Institute 2015)

3.2.3 Neuromuscular Scoliosis

Different neurological illnesses can cause dysfunction in the central nervous system (CNS) and peripheral nervous system (PNS) affecting the neuromuscular structures of the spine. The muscle balance is not equal between the structures, which can be either due to neural or muscular defects. (Kerttula, Schlenzka & Tallroth 2004,

2298.) This type of scoliosis causes clear malpositions and asymmetry in the trunk. Neuromuscular scoliosis is a condition, which worsens by time and in the worst cases causes an early death. (Ryöppy 1997, 121.)

What makes treating neuromuscular scoliosis especially difficult is the fact that the spine might continue curving even after the growth period has ended (Pihlajamäki & Ruuska 2010, 3). Not to mention the fact, that the decision to operate a neurologically disabled child takes more time than in other scoliosis cases. Surgery is the most commonly used treatment method for neuromuscular scoliosis but also using casts and orthotics can be a treatment option as well though neuromuscular scoliosis patients cannot use hard plastic orthotics such as the Boston brace. (Helenius & Pajulo 2015, 1785.) There are multiple conditions that can be behind neuromuscular scoliosis, those include Cerebral Palsy (CP), Polio, Myelomeningocele (Spina Bifida), Muscular Dystrophies, spinal muscular atrophies, spinal injury and stroke (Ryöppy 1997, 141; Pihlajamäki & Ruuska 2010, 3). Neuromuscular scoliosis is most typically seen as a curve shaped as a C-letter (Kerttula, Schlenzka & Tallroth 2004, 2298).

3.3 Non-structural Scoliosis

Non-structural scoliosis, also known as secondary or functional scoliosis, is caused by a functional disturbance where the body compensates the bodily movements from pain or some other irritation thus causing an unwanted curve to the spine (Crowther 1999, 139). In forward flexion the deformity disappears if the scoliosis is non-structural, while in structural scoliosis the posterior rib hump becomes more prominent. There is often no vertebral rotation accompanied with the lateral curve as it is in structural scoliosis. Functional scoliosis is a secondary symptom to e.g. poor posture, nerve root irritation, and inflammatory condition of the spine, leg length discrepancy, hip contracture, hysteria or acute lumbago. When the primary cause of the scoliosis is found and treated, the spine straightens automatically finding its' natural kyphotic and lordotic curves. (Magee 2008, 478.) Pain is more prominent in non-structural scoliosis than in structural scoliosis (Helenius 2013, 1).

4 TREATMENT OF ADOLESCENT IDIOPATHIC SCOLIOSIS

The treatment of scoliosis can be either conservative management including the screening of patients, brace treatment and scoliosis specific therapeutic exercising or operative management. The treatment, which will be applied, depends on the magnitude of the scoliosis curve. The professionals assess the patients and offer the best-suited options for them. (Helenius 2013, 1.)

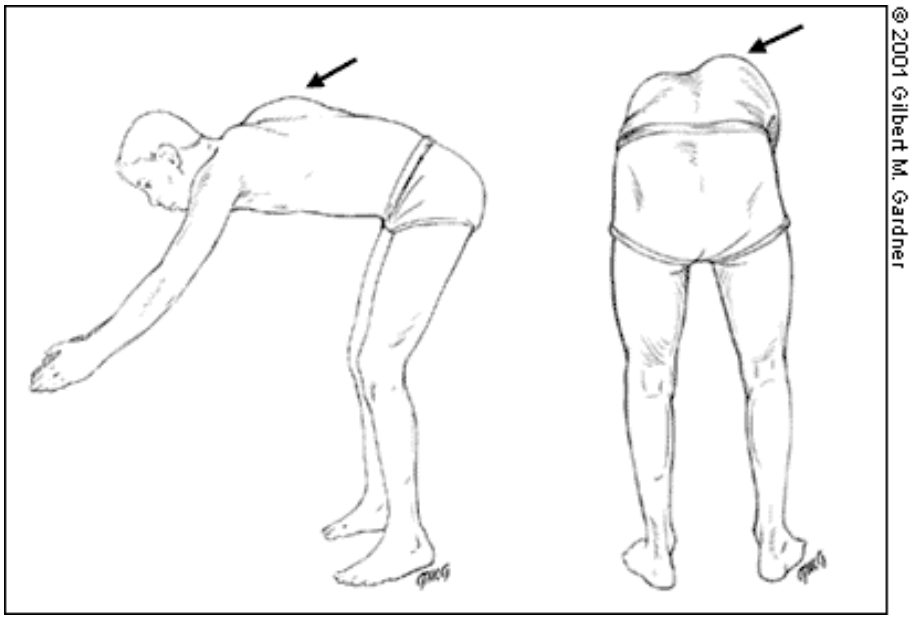
4.1 Conservative management

Conservative management is defined on the Website of the Free Medical Dictionary as "treatment designed to avoid radical medical therapeutic measures or operative procedures" (The Website of Medical Dictionary 2015). In scoliosis this refers to treatment that does not involve an orthopaedic surgery. Conservative management of scoliosis consists of screening and follow-up of new cases, orthopaedic bracing and sometimes therapeutic exercising. (Helenius 2009, 1169.)

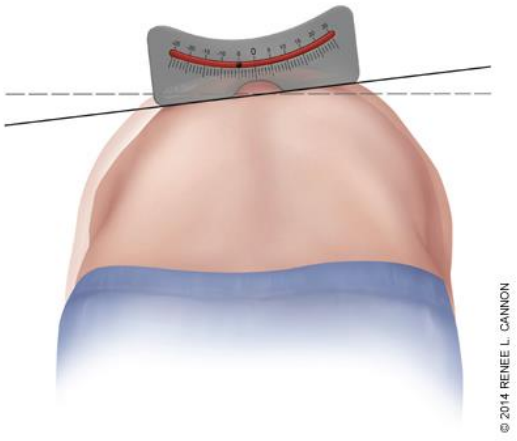
4.1.1 Screening, Follow-up and Prognosis of AIS

Even 4% of the adolescents have a curved spine, which meet the requirements of scoliosis (Kerttula, Schlenzka & Tallroth 2004, 2298). This is the reason why in elementary and junior high schools scoliosis screenings are done to find those with scoliosis. This is essential so that the children who have scoliosis would be referred to receive treatment as soon as possible. In puberty, the growth periods can be rapid and the worsening can happen in a short time. (Kerttula, Schlenzka & Tallroth 2004, 2298.) A postponed diagnose worsens the effect of conservative treatment and a surgery is most likely needed. The authors Kerttula, Schlenzka and Tallroth speculate that the screening of scoliosis is not functioning properly in Finland and is yet to be improved, the reason being the decreased number of cases in the need of orthotic bracing and the stabile prevalence of the condition. (Kerttula, Schlenzka & Tallroth 2004, 2298.)

The Adam's forward bending test is a common screening method (picture 8). It is the most powerful determinant of the occurrence of scoliosis (Nissinen 1996, Abstract; Kerttula, Schlenzka & Tallroth 2004, 2298.) Some curves are yet so small and unnoticeable in standing positions that only forward bending reveals the scoliosis (Kerttula, Schlenzka & Tallroth 2004, 2298). In the test the patient is asked to bend down slowly while keeping the palms together. The therapist observes for trunk asymmetry or a rib hump, which becomes more dominant in a flexed position. If there is some seen asymmetry, the therapist may proceed to measure the inclination angle with a scoliometer (picture 9), which will help to determine which patients need to have radiographs taken of. (Horne, Flannery & Usman 2014, 193.) If the result from a scoliometer is less than six degrees, a check-up every four or six months is enough a treatment. If the degree is 6° or more, x-rays are taken. (Kerttula, Schlenzka & Tallroth 2004, 2298.)



Picture 8. Adam's forward bending test is often used for screening of scoliosis. The arrows point on the clearly visible rib hump, which becomes more dominant in a flexed position. (From the website of American Family Physician 2015)



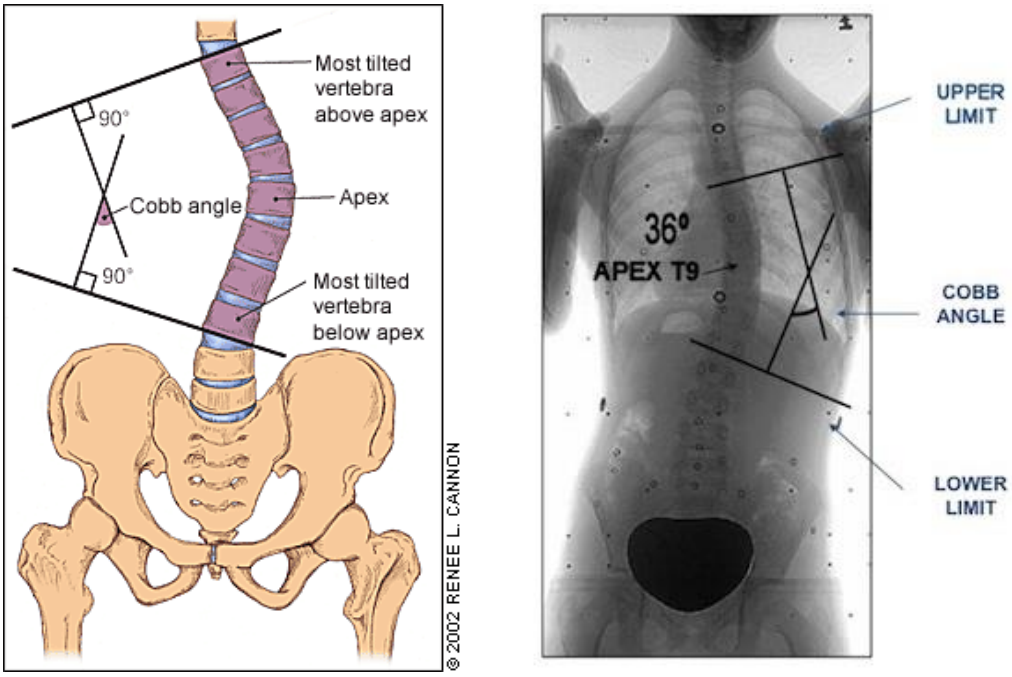
Picture 9. Measuring the inclination angle of the spine with a scoliometer (From the website of American Family Physician 2015).

There are many methods to measure the angle of scoliosis. Measuring the magnitude is a concrete method for following the development of the curving. When the curve goes over a certain angle the needed treatment is started depending on the severity of the curvature. The most common method for assessing the curve is the Cobb method, which has been in common use since 1948 after Doctor John R Cobb developed it. It is also most common scoliosis measurement method in Finland. (Helenius 2009, 1168; Kerttula, Schlenzka & Tallroth 2004, 2298.)

The Cobb angle (picture 10) is measured from an x-ray picture, which is to be taken while the patient is standing. Two extended lines are drawn linearly with the upper border of the top vertebra and bottom border of the end vertebra, which are the first and last vertebras that are tilted and involved in the curve. Then two lines are drawn, which are perpendicular to the first two lines and the crossing of these lines defines the Cobb angle. (Helenius 2009, 1168.)

The spine is defined with scoliosis if the Cobb angle is 10° or more from a posterior-anterior (PA) x-ray, which is a key element in diagnostics (Helenius 2009, 1168; Kerttula, Schlenzka & Tallroth 2004, 2298). The angle of the spine calculated with the Cobb method defines what kind of treatment the professionals need to prescribe to the patient based on the guidelines (table 1). Angles between 15-20° are considered to be that of a mild scoliosis, needing regular check-ups every 3-4 months for following the development and possible progression of the curve until the cessation

of the bone after which the progression normally stops. If the angle is 20-40° more medical attention by the specialist is needed and commonly first conservative management, bracing, is recommended to slow down the progression of the curve. (Crowther 1999, 139.)



Picture 10. Cobb method, a tool with which on can define the angular measurement of the curve of scoliosis (From the website of American Family Physician 2015 and from the website of Posturetek 2015).

The prognosis of scoliosis depends on the onset and the location of the scoliosis. Lumbar scoliosis typically has a better prognosis when compared to thoracic scoliosis, where the deformity is also more visible due to the rib hump. The later the onset, the more likely it is for the medical treatment to help and slow down the curving. Also, in this situation there is less time for the spine to curve before the curving stops after the end of the period of spinal growth. (Adams & Hamblen 2001, 181.)

AIS patients whose curves are 50° or more require a spinal operation (Helenius 2009, 1168). Curves that are over 50° tend to continue curving even after bone has ossified. A scoliosis is defined as severe scoliosis if the Cobb angle is over 70°. (Helenius & Pajulo 2015, 1785.) If the curve is greater than 70° there is an 80% chance that the person has a restrictive lung disease and the lung capacity is limited as a result of the

severe deformity. Patients with curves over 70°, which are left without medical attention, have a greater risk of early death. (Helenius 2013, 63; Helenius & Pajulo 2015, 1785.) Most commonly these patients have neuromuscular scoliosis instead of idiopathic scoliosis, which rarely reaches the angle of a severe level. Also, Finnish screening system is so efficient that most of the AIS cases are identified before they reach the operative level (>40°). Only in rare cases, such as teenage pregnancy or eating disorder where the young avoids public health care check-ups, AIS develops into a severe one reaching 70° angle. (Helenius & Pajulo 2015, 1785.)

Table 1. Cobb's angle in relation to the recommended treatment method. The recommendations vary depending on the references (Helenius & Pajulo 2015, 1785).

Cobb's angle	Treatment method
10-20°	Follow-up
25-40°(45°)	Bracing
>40°(-50°)	Scoliosis surgery

4.1.2 Orthopedic Bracing

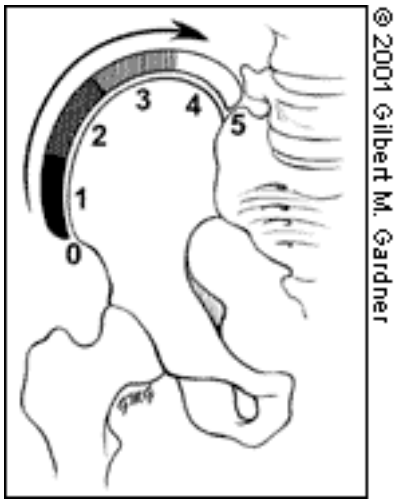
Orthotic bracing is the most common conservative treatment method used worldwide for managing and slowing down the further curving of scoliosis in adolescent Idiopathic patients (Weinstein 2001, 371). There is no evidence that using a brace would straighten the curved spine but rather slow down the condition and maintain the curve at the starting level. The total effect of maximal correction using bracing has been studied to be 10°. (Helenius 2009, 1168.)

There are multiple braces developed for different scoliosis types, each brace is custom-made and individually designed to meet the clients' needs. Ideally, a brace is prescribed to prevent the need for surgical operations, if the scoliosis is still in maintainable angle. A successful bracing is achieved with a good co-operation between the patient, the parents and the professional team. It has been estimated that the general effect of bracing treatment for the back is approximately 10° of the natural de-

velopment. Orthopaedic bracing is started when the curvature exceeds 20-25° in Cobb angle and is normally continued until the end of the bone growth if there is no sudden worsening of the condition. (Helenius 2009, 1169.)

Adolescents and children are most often the ones required to wear the orthotics. Idiopathic scoliosis affects patient's self image and confidence. Braces are often uncomfortable and too noticeable, which makes accepting this management method difficult for the young clients, who are already sensitive of their appearance. Also, in that age the clients are continuously growing in height and especially girls are developing more feminine features with hips growing wider and breast growth making the fitting more challenging. (Chan et al. … 2008, 137-139; Carvalho de Abreu et al. … 2012, 1.)

Bone maturity can be diagnosed from an x-ray picture with two different methods. One is a Risser grading method (picture 11) where an x-ray is taken of the iliac crest. The bone growth has stopped, if the grade is 4 and fully ossified if the grade is 5. Grades less than four mean that there is still some growth left (table 2). (Ryöppy 1999, 120.) Another method for assessing the grade of bone maturity with which one can determine how much growth there will be expected is Greulich-Pylen (G-P) method. In this method an x-ray is taken of the left hand and similar grading is applicable. These are essential tools for giving a prognosis to the whole curving process. (Kerttula, Schlenzka & Tallroth 2004, 2298.)

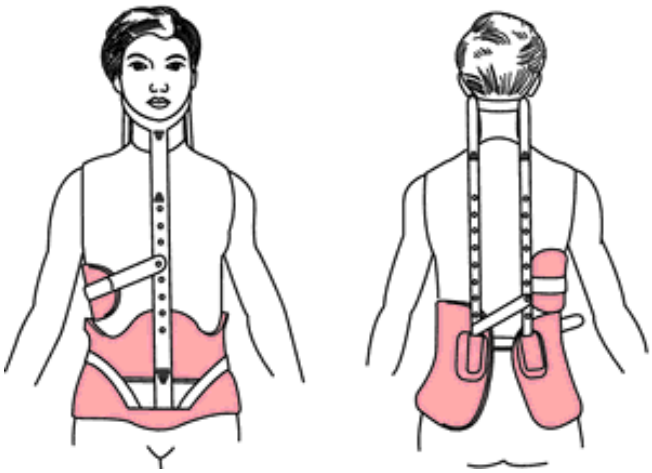


Picture 11. Risser grade from 0-5 measured from the iliac apophysis, 0 meaning no ossification and 5 meaning complete bone fusion. (From the website of American Family Physician 2015)

Table 2. Risser grading. (Ryöppy 1999, 120.)

Risser 1	75% growth left
Risser 2	50% growth left
Risser 3	25% growth left
Risser 4	0% growth left
Risser 5	Apophysis ossified →spinal growth has finished

Milwaukee distraction brace also known as CTSCO (cervico-thoraco-lumbo-sacral orthosis) was for many years the most common brace type (picture 12). Although Doctor Walter Blount developed it already in 1950, Milwaukee brace still meets the demands of today's requirements. The basic method in Milwaukee bracing is the three-point correction method where a ring-shaped occipito-cervical support is connected to a pelvic band with an additional lateral pressure to the apex of the curve with a padded support. Milwaukee brace is mostly used for kyphotic conditions and very seldom for Adolescent idiopathic cases. Milwaukee brace is studied to be effective only if it is being used for 23 hours per day with one-hour-long brake for showering, dressing up and exercising purposes. (Adams & Hamblen 2001, 181.) Also, the users of the Milwaukee brace appeared to have more psychological problems due to the clumsy appearance of the orthotic and high hourly usage demands (Ryöppy 1997, 119; Helenius 2009, 1168).



Picture 12. Milwaukee Brace demonstrating the three-point correction method. (From the website of The Free Dictionary By Farlex 2015)

The Boston brace (picture 13) was developed soon after the Milwaukee brace in 1960 when the need arose for creating a brace that would be accepted better by its' users. Boston brace is most commonly used for lumbar or thoraco-lumbar curves where the apex is located below Th-9 level, thus the name thoraco-lumbo-sacral orthosis (TLSO). Boston braces mechanism is to flatten the excessive lumbar lordosis with only a two-point correction. This controls the lateral curving of the spine. What makes Boston brace more accepted compared to the Milwaukee brace is that it is an underarm brace, which is more unnoticeable compared to Milwaukee brace and is much easier to hide under clothing. Another underarm brace, Lyon brace, is instead used for curves with apex located in thoracic or thoraco-lumbar area. (Crowther 1999, 139-140.)

Picture 13. Boston brace, front and back view. (From the website of Orthotics Prosthesis New England 2015)

It is possible that in some cases, there are more than one braces prescribed for one patient. Typically the Providence or Charleston bending brace are offered to give some extra support during the night-time additionally. There are also many newly developed optional braces on the market, which offer more elasticity and are more comfortable for its' user. The evidence of their efficiency is yet to be proved. (Crowther 1999, 139-140.)

4.1.3 Therapeutic Exercising

There is no concrete evidence that exercising alone is helpful for slowing down the curving of the spine (Adams & Hamblen 2001, 183; Weinstein 2001, 371). Structural scoliosis cannot be managed with only physiotherapy alone. Oppositely, the symptoms in non-structural scoliosis can be relieved by physiotherapy, such as nerve root irritation. (Hakkarainen 2007,1.) More studies are needed to find out what are the effects of exercising for scoliosis patients (Helenius 2013, 1).

Still, individually designed exercising programs are found to be efficient for scoliosis patients in all the phases of scoliosis treatment. The scoliosis patients should not be restricted from physical activities and exercising. It has also been found, that people

with scoliosis have more problems in their balance than those without scoliosis. (Hakkarainen 2007,1.)

The client who wears a brace is encouraged to exercise daily with and without the brace. Exercising without a brace is recommended to prevent the total dependency on an external support and rather activate the core muscles to work as an internal corset. It is also recommended to exercise with the brace on to activate the core muscles inside the brace and to keep the correct posture throughout the day, not only during the short period during the off-time. The muscle force takes away the extra load from the bony structures, which already suffer from asymmetric loading. (Romano, et al. … 2015, 3.)

The main idea in exercising for scoliosis patients is to correct the motor control strategies of movement and posture and to turn them into automatic patterns. The aim is that through patient education and active muscle training, the patient is able to correct his posture automatically and achieve the needed stability and improve symmetrical spinal alignment. One recommended and concrete exercising method is an active self-correction, where the patient tries to correct the posture as well as he or she is capable to achieve three-dimensionally (picture 14). (Romano, et al. … 2015, 3.)

Picture 14. Left picture showing patient's normal curve pattern, while picture on the right demonstrates the effect of active self-correction on the spine. (From the website of scoliosisjournal.)

4.2 Scoliosis Operations

When the Cobb angle is 40-50° or greater and there is still growth of the spine expected, spinal fusion operation is performed (Helenius 2009, 1169.) In addition, those who are diagnosed with scoliosis who are almost at the end of their bone growth period with curves, which are great in magnitude, are also directed to surgical treatment (Pihlajamäki & Ruuska 2010, 15).

The purpose of the scoliosis surgery is to fuse all the needed joints of the vertebras involved in the primary curve, thus the name spinal fusion. After the instrumentation of the apex of the spine, the instrumented area is also ossified to secure the long lasting end result. (Ryöppy 1997, 120.) Normally, the rods or other metal instrumentations used in the operation are permanently left on the operated area (Pihlajamäki & Ruuska 2010, 15; Ryöppy 1997, 121). Scoliosis surgery is the only treatment method for scoliosis, which can correct the already curved spine (Helenius 2009, 1169; Ryöppy 1997, 120).

The aim of the surgery is to slow down or to stop further development of curving. Depending on the operation method and the individual, the operation can straighten the spine up to 50°-60° from the original curve. The orthopaedist always assesses individually, how much correction can be done in safe measures. (Pihlajamäki & Ruuska 2010, 15.) Other goals of the surgery are: to achieve a good balance in the spine between the saggital and coronal planes, to achieve an ideal yet safe amount of correction in the spine, to stop the further curving of the spine and to get the patient to return to his normal function as soon as possible after surgery. Importantly, the spine will not be corrected to achieve a good-looking and cosmetic result, thus the spine will not necessarily be vertically straight. (Weinstein 2001, 408.)

Before the operation, a standing posterior–anterior (PA) x-rays are taken of the spine. Additionally, x-rays with patient bending laterally are also taken. These x-rays help in defining the primary curve and how large an area will be operated and ossified. The surgical treatment method will be also decided based on the x-rays. (Pihlajamäki & Ruuska 2010, 15.)

There are multiple surgery techniques for scoliosis operations. The first surgical method in treating scoliosis was the Harrington rod method, which was developed in 1962. It is a posteriorly performed technique, in which two metal rods are inserted in the concavity of the curve between two hooks. The field of scoliosis treatment has advanced since, thus new and much better techniques have been developed. (Helenius & Pajulo 2015, 1785.)

How the selection of a surgery method is made, depends on the area of the apex and the preferences of the operating surgeon. The operation may be done posteriorly, anteriorly or with these two methods combined by placing an internal corrective implant to the spine. Lumbar scoliosis is typically operated anteriorly while both thoracic and double curve scoliosis are operated posteriorly. (Pihlajamäki & Ruuska 2010, 15.)

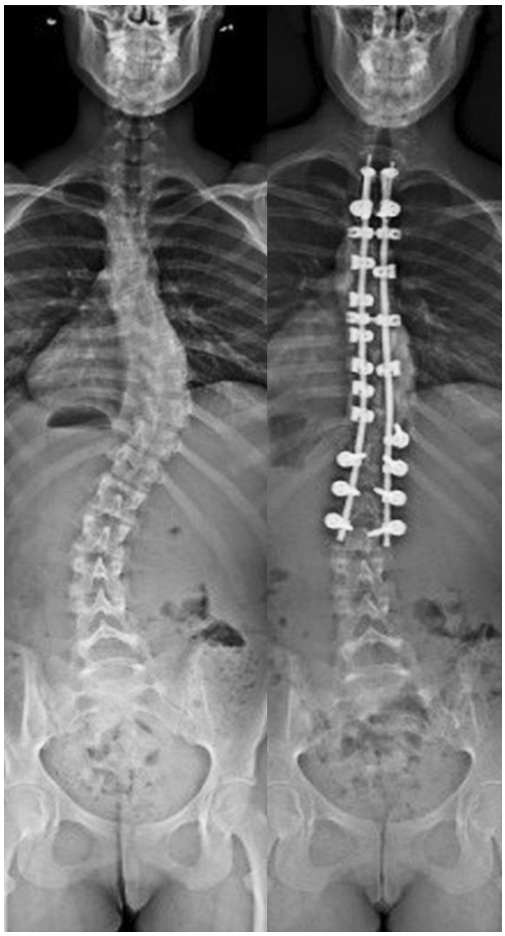
The advantage in posterior techniques, such as the Luque technique or Cotrel-Dubousset (C-D) instrumentation, is the higher possibility of correcting the rib hump in thoracic spine (picture 15) and securing the function of the spine. Posterior surgery methods are the most beneficial for greater curves while anterior methods are better for shorter curves. (Crowther 1999, 141.)

In anterior methods, such as Zielke instrumentation method, the curve can be straightened more successfully on a smaller area in the lumbar spine. This means that there are more segments left without fixation leaving the spine more mobile. The downside of an anterior surgery is the need to cut through the ribs. A pedicle instrumentation method provides an option where the ribs are not cut. (Crowther 1999, 141.)

The combination of posterior and anterior operation is used more rarely and only in special occasions e.g. in adult patients or in severe scoliosis cases (Crowther 1999, 141; Helenius & Pajulo 2015, 1785). Nowadays, this type of operation, which is performed from both sides have become more rare after the studies have shown several contraindications of this surgery method. Restricted lung capacity, extremely long operation duration, and vascular paraplegia are some of the contraindications. Sometimes in severe scoliosis cases where the apex is sharply curved, removing a part or a

whole vertebra is a better option, when other techniques are not sufficient enough. This provides up to 65% correction. (Helenius & Pajulo 2015, 1785.)

Scoliosis operations are challenging and time consuming operations that require proper preparation and special equipment. This is the reason why the operations are centralized to certain hospitals with operation theatres designed and specialized for scoliosis surgeries with hygienic facilities and experienced orthopaedists. In Finland, the hospitals that offer scoliosis surgery are centralised to Tampere, Oulu, Helsinki and Turku University Hospitals. (Pihlajamäki & Ruuska 2010, 16.)



Picture 15. Pre- and postoperative radiographs showing the obtained correction in the thoracic scoliosis. (Blondel et al. … 2012, 1969)

5 POST-OPERATIVE MANAGEMENT

Scoliosis patients need extra monitoring after their surgery in paediatric intensive care unit, (ICU) (Hartikainen 2004, 293). The reason for ICU care is the need for proper respiratory management. After the one-day-long surgery the patient spends approximately one to two weeks the ward. They are given pain medication and the operation wound is taken care of to rule out any possible complications. Proper pain management is the key element for fast recovery. Breathing exercises can be started as soon as possible after the pain medication has started affecting. (Helenius & Pajulo 2015, 1785.)

Rotational movements are restricted for some time to secure the proper healing of the surgery area. A physiotherapist, who is part of the multiprofessional team, gives some specific rehabilitative exercises for the patient. It is important to be able to walk and stand as soon as possible after the operation to restore the normal function of the body such as the activation of the lungs. The aim of rehabilitation is that sitting would be possible during the first day and standing after second day post-operation. The physiotherapist in charge gives breathing exercises for the patient, which helps in removing unwanted fluids from the lungs. (Vartiainen & Ylipukki 2010, 19-20.)

Thoraco-lumbo-sacral orthosis (TLSO) may be prescribed post-operatively to immobilize and secure the healing process of the surgery wound. This has been found to decrease some post-operative discomfort. The length of the period of using the TLSO may vary from 8 weeks to even 6 months. (Crowther 1999, 141.) After scoliosis operation, the patient will have follow-ups until 1 year to 4 years post-operation or until the growth period has ended. Great results have been accomplished with scoliosis surgeries. (Pihlajamäki & Ruuska 2010, 16.)

Physical activities are restricted for the first six months after surgery. Some orthopaedist recommend light activities such as jogging already 3 months post-operatively. The spine ossifies fully around one year after surgery, this is why high velocity contact sports are restricted up to one year post-operatively to prevent any accidents on the operated area. Because the spine is fused, it loses its' ability to bend

and function normally. It might take long time for the patient to get used to the new spine and how it functions. (Tarrant et al. … 2014, 1471.)

Complications are uncommon in scoliosis surgeries (Pihlajamäki & Ruuska 2010, 15). Sometimes re-operations are performed, when the first operation has failed or some other complications appear. Still, all operations carry a risk of neurological complication. (Adams & Hamblen 2001, 183.) Surgeries for severe scoliosis carry a greater risk of complications. These complications include haemorrhage (excessive bleeding), hyperthermia and infections due to long operation times and complications of the respiration and lungs. (Helenius & Pajulo 2015, 1785.) Although there has been some great surgical improvement in scoliosis correction operations, the focus should not be only on the angular amount of spinal correction but instead on the quality of life of the patients suffering from AIS and their perception of the deformity (Han, Xu, Yang, Yao & Zhang 2015, 12-16).

6 A LITERATURE REVIEW

According to Johansson et al (2007, 3) a literature review provides an entity of a certain subject for the reader. It gives an idea of how much the subject has been already studied before and what kind of evidence there is existing of the selected subject. It is important to remember that literature review can be a large review including several studies or a small review with only two studies. Also, a literature review is just a study based on either one professional's or professional group's point of view. A common feature in all literature reviews is that there has to be at least some studies made of the chosen subject area. Literature review most often concentrates on studies that have been made during a certain time period and it is recommended to update the review when new studies are made of that same subject. (Johansson et al. … 2007, 2.)

6.1 Literature Review Process

According to Johansson et al (2007,5) the literature review procedure can be divided into three different phases: planning, execution and reporting phase (table 3). First, in the planning phase, before the actual research is started the researcher analyzes if there is a need for a literature review of that specific subject. If there is such a need, the research procedure starts with defining one to three research questions to which the whole research in the end gives an answer for. The researcher needs a problem that can be solved. Also, in this phase the in- and exclusion criteria is defined. (Johansson et al. … 2007, 2.)

In the second phase, the execution phase, the researcher performs the research using the defined search terms in the wanted databases. After this, the researcher reviews all the articles and applies the in- and exclusion criteria on the studies, and this way determines, which studies will be kept. The criteria can help in defining the participants, intervention, outcomes or the design of the studies. Also, writing down the search history in the form of a figure or a table is a good way to inform a systematic research procedure. The more detailed the study process has been described in the process, the more reliable and traceable it is. (Johansson et al. … 2007, 6-7.)

In the last phase, the results will be presented and a conclusion drawn of the studies involved in the review. Literature reviews differ widely from their quality as any other studies. They are evidence-based studies, which critically analyze the available studies. In the end it tries to define why the review was important and how it adds up with the previously made studies. Typically a literature review also provides a good theoretical background for the main subject of the review. (Johansson et al. … 2007, 7 & 58.)

Table 3. The three different phases of writing a literature review according to Johansson et al (2007, 5).

Phases	Description
1. Planning	• Reviewing previous articles • Analyzing the need for a review • Defining 1-3 study questions • Choosing databases and search terms • Determining the inclusion and exclusion criterion
2. Execution	• Performing the search • Choosing the studies • Writing down the research history
3. Reporting	• Reporting the outcomes • Writing a conclusion

6.2 Evidence Based Practice and Studies

Evidence-based practice (EBP) is a combination of clinical expertise opinion, scientific evidence and client or patient perspective on a certain subject that provides a high-quality service (picture 16). The aim of EBP is to provide a client-centred practice and to offer the best up-to-date service based on the recent evidence, which is optimal to the situation of the client including his or her individual preferences. EBP is a process that needs continually updating and evolving to meet the continuously changing requirements. (Website of American Speech-Language-Hearing Association 2015.)

A literature review is an evidence-based study. The key steps in a study, which is evidence based, are the following four: (1) framing the clinical question, (2) finding the evidence, (3) assessing the evidence and (4) making a clinical conclusion based on the evidence. These requirements are met also in a literature review. (Website of American Speech-Language-Hearing Association 2015.)

Picture 16. Evidence based practice and it's integration. (From the website of Evidence Based Practice 2015)

6.3 Purpose and Aim of Thesis

The purpose of this thesis is to gather evidence-based and up-to-date researches about AIS and its' post-operative physiotherapy management. The client of the thesis is Satakunta Central Hospital (Satakunnan Keskussairaala), which is located in the west side of Finland, a city called Pori and is part of Satakunta Hospital District (Satakunnan sairaanhoitopiiri). The need for such topic came from the physiotherapists working at the paediatric outpatient clinic. They wanted to have concrete updated information of post-operative physiotherapy for scoliosis surgery patients. The aim is that the literature review could be a tool of which the physiotherapists would benefit from and would help in their clinical work. The study question for the thesis is the following question:

1. What are the current evidence-based physiotherapy recommendations for post-operative management after AIS surgery?

7 RESULTS

Before the research strategy was carried out, the author read a few other literature reviews to get an idea of their structure and the needed procedures. A staff member of the University library gave a private lesson of research databases and their search methods. The first step in writing a literature review is a thorough planning before the actual database research, which was accordingly carried out. (Johansson et al. … 2007, 5.)

7.1 The Search Strategy

The database search was made on the 23.10.2015 and 24.10.2015. The search terms, which were used in the search were “adolescent idiopathic scoliosis” and “postoperat*” combined with “rehabilitation”, “physiotherapy” or “physical therapy”, “management”, “scoliosis operation” or “scoliosis surgery”. The databases, which were chosen, were Pubmed, Ebsco and ScienceDirect. Table 4 demonstrates the search results graphically.

Table 4. The results with different key word combinations from the used databases.

Entry terms		**Pubmed**	**ScienceDirect**	**Ebsco**
"Adolescent Idiopathic scoliosis" AND postopera-ti*	AND rehabilitation	34	118	112
	AND physiotherapy OR "physical therapy"	6	130	168
	AND management	121	312	3
	AND "scoliosis surgery" OR "scoliosis operation"	87	184	5
TOTAL		**248**	**744**	**288**

7.2 Study Selection

Figure 1, the flowchart, demonstrates how the study selection was made after the search procedure was done with the selected search terms. At first, there were 1280 hits from the three selected databases. From that amount, 1024 studies were removed after applying exclusion criteria on the studies leaving 256 studies to be remained. First off, the studies had to be applied for human beings. Secondly, the studies had to be recent, between the years 2010-2015. Other inclusion criteria consisted of the following requirements: the studies had to be made of young AIS patients, they had to concentrate on post-operative management and the study language had to be English. Also, the studies were excluded if they focused on pain, surgical complications, medical procedures and medication (such as anaesthesias), surgery techniques and were review articles or chapters of books instead of studies. After this, all the duplicates were removed leaving only eight studies in the review, which were involved in the final data analysis.

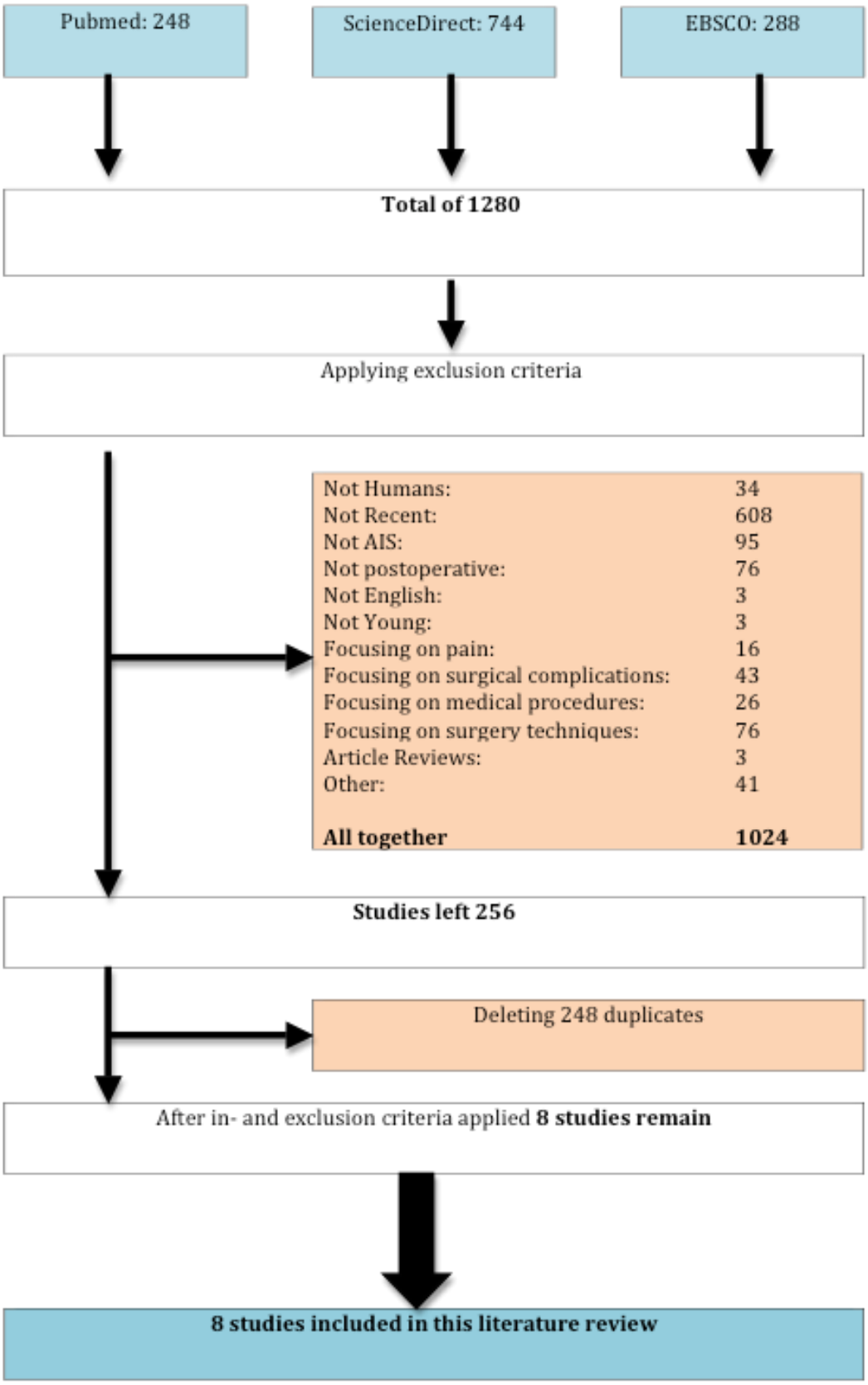


Figure 1: Flow chart of the study selection.

Table 5: Summary of the included studies.

Title, Author & Publication year	Purpose/Objective	Design	Subjects	Outcomes/Results	Relevance to study question
"Timing and Predictors of Return to Short-term Functional Activity in Adolescent Idiopathic Scoliosis After Posterior Spinal Fusion" Tarrant et al 2014	To assess the timing and predictors of return to short-term functional activity, school or college, in patients with AIS after posterior spinal fusion (PSF). Also to demonstrate actual versus anticipated timing of return to school and physical activities post-operatively.	A Prospective Study	Subjects with AIS who underwent PSF, total of 77 subjects	The majority of patients with AIS can expect to return to school/college full-time by 16 weeks (77.3%), later than it has been recommended. The median time was 10 weeks. If the curve was greater than 70° in addition with post-operative weight loss more than 5 kg and minor respiratory complications the incidence predicted a delay in return to school. The return to unrestricted physical activities (PAs) was studied to be at 52 weeks. Only 3 % did not return to physical activities due to	Return to functional activities happened after 52 weeks. By 24 weeks 51,4% and by 52 weeks 88,5% of subjects had returned to unrestricted PAs aka contact and competitive sports. The subjects can return to part-time PAs earlier, which included gentle swimming, jogging, cycling, pilates and other non-contact sports. Return to school and college happened later in most of the cases than is recommended in guidelines and

				chronic back pain.	post-operative leaflets (4-6 weeks).
"Patient Factors are Associated With Poor Short-term Outcomes After Posterior Fusion for AIS" Basques et al 2014	To find out what is the frequency of and what factors are associated with postoperative (1) adverse events (AEs), (2) extended length of stay (LOS) and (3) readmission in patients and total hospital cost.	A Prognostic Study	Patients aged 11 to 18 years old who underwent PSF, total of 733 subjects from which 30,6% were overweight or obese.	(1) Out of the patients 3,7% had AEs including nervous injury or an infection and severe AEs were associated with overweight or obesity. (2) Extended LOS occurred for 8,2% of the patients and was associated with greater than 13 levels instrumented and if the operative time was extended over 365 minutes. (3) Readmission occurred for 1,5% of the patients.	Obesity stands as a risk for post-operative AEs.
"Reciprocal Sagittal Alignment Changes After Posterior Fusion in the Setting of AIS" Blondel et al 2012	To evaluate sagittal plane reciprocal changes leading to flatback after posterior spinal fusion in the setting of AIS.	A Retrospective Study	Thirty consecutive adolescents (mean age 14.6 years) with AIS Lenke curves 1, 2 or 3	Between preoperative and post-operative (24 month) follow-up a significant reduction of Cobb angle was observed (53.6° vs.	These results underline the necessity to restore optimal thoracic kyphosis, whatever the surgical strategy used, in order

				17.2°). A significant improvement of the instrumented thoracic kyphosis (TK) was noted as well as in lumbar lordosis (LL), which occurred at 3 months post-operatively. TK correction was correlated with the improvement of LL.	to offer adolescents suffering from AIS optimal sagittal alignment as they mature into adulthood.
"What is the Influence of Surgical Treatment of AIS on Postural Control?" Carvalho de Abreu et al 2012	To evaluate the effect of surgical treatment on the control of upright balance in AIS. The mean amplitude and velocity of the centre of pressure (COP) evaluations in the anterior-posterior (AP) and medial-lateral (ML) directions were obtained before surgery and at 7, 30, 60, 90-days in an upright position.	A Comparative Study	Thirty adolescents divided into two groups: Group C (n=15) without scoliosis and Group S (n=15) with scoliosis.	Group S had larger AP and ML mean amplitude and mean velocity before and after surgery compared with group C. This suggests that a sensory motor impairment or sensory integration problem could explain the balance control alterations more than biomechanical factors in the AIS.	Physiotherapists could work post-operatively to reduce sensory motor impairment.

"Scoliosis Surgery in Patients With AIS Does Not Alter Lung Volume" Sarwahi et al 2014	To determine the change in lung volume after the surgical correction of scoliosis using a volumetric reconstruction of lung volume from computed tomography (CT) scans. Previously published CT-based volumetric studies in patients with scoliosis have previously shown differences in lung volume and lung volume ratio, when compared with a normal population. To date, no study proves this.	A Retrospective Study	A total of 29 patients (23 females, 6 males) with AIS who had pre- and postoperative CT-scans on file. Median preoperative major Cobb angle was 53.2°.	Neither total lung volume nor left/right lung volume ratio changed significantly postoperatively. Surgery did not significantly change total lung volume or the ratio between R and L lung volumes. Postoperatively the mean Cobb angle value was 15° resulting in 70% Cobb correction. In short, this study concludes that surgical correction of AIS improves the thoracic symmetry caused by scoliosis but does not change lung volume.	Physiotherapists could work on post-operative dynamic breathing exercises such as deep expiration and inspiration involving movement from the chest and rib cage.
"Level of Play: Return to Sports Following Surgery for AIS" Lonner et al 2014	To assess the return to sports participation in operatively treated AIS patients via post-operative questionnaires.	A Retrospective Study	Operative AIS patients presenting for their 1- or 2-year postoperative visits, 38 subjects in total, median age 14.2 yrs.	36/38 returned to their sports after surgery. Median times to begin training after surgery was 3-6 months and to fully return to sports was	Physiotherapists who work postoperatively with the patients could via interview find out what could be the reasons why the

				6-12 months. Among 36 patients 29 were able to return to their previous or higher level competitive sports. Time at play was significantly decreased after surgery. There were no significant changes in patient-perceived physical potential in sports.	decrease has happened.
"Increased Body Mass Index Negatively Affects Patient Satisfaction After a Posterior Spinal Fusion and Instrumentation for AIS" De la Rocha, McClung & Sucato 2014	To review the influence of BMI on the follow-up clinical and functional outcomes after posterior-only fusion (PSF) and instrumentation for adolescent idiopathic scoliosis in a larger patient cohort.	A Retrospective Study	Patients treated with PSF for adolescent idiopathic scoliosis from 2002 to 2009 at a single institution. There were 3 categories: underweight (UW), normal weight (NML), and overweight (OW). A total of 459 patients at an average of 15.0 years.	At follow-up, preoperative overweight adolescents reported more pain and lower mental, activity, and appearance domain scores after surgery than UW and NML patients despite equal percent curve correction and less postoperative physical activity.	This information may help the professional with preoperative counseling of OW patients by stressing that their own assessment of outcome is influenced by BMI, which may help promote a healthy weight management program in this patient group.

"The Biomechanical Effects of Spinal Fusion on the Sacral Loading in AIS" Pasha et al 2015	To evaluate the impact of the scoliosis spinal fusion on the transferred load between the spine and pelvis.	A Comparative Study	Total of 9 AIS female subjects who have undergone PSIF, on average 15 years old.	The impact of the surgical spine correction on the biomechanical loading on the sacrum was highlighted in AIS subgroups. The position of the stress distribution centroid on the sacrum superior endplate to the central hip vertical axis was significantly different between pre- and post-operative patients.	The impact of the scoliosis spinal fusion on the transferred load between the spine and pelvis was evaluated. The biomechanical loading of the sacrum endplate was related to the post-operative postural balance and compensatory changes in the spino-pelvic alignment after scoliosis surgery.

7.3 Current Evidence Based Physiotherapy Management Options

The results presented in the studies varied quite largely between each other and not just one common result topic could be found. The research question appeared to be variable and rather exact compared to the results given by the studies, which were not concrete or practical, as the author had assumed. At this point it was too late to change the research question. Regardless, interesting results were found. The results presented here are only suggestions what kind of physiotherapy could be applied for the AIS patients based on the problems found from the studies. Further studies are needed to discover what could be the more specific and practical methods of physiotherapy. (Tarrant et al. … 2014, 1471-1477; Lonner et al. … 2014, 48S; Sarwahi et al. … 2014, E399-E405; De la Rocha, McClung & Sucato 2014, 208-213; Basques et al. … 2015, 286-294; Pasha et al. … 2015, 981-987; Carvalho de Abreu et al. … 2012, 886-590; Blondel et al. … 2012, 1964-1971.)

There were nevertheless some similarities between the eight studies. Two of the studies focused on the return to school and sports of AIS patients postoperatively. Two studies focused on the effects of obesity or increased BMI on postoperative management. One study studied about the changes in lung volume while the last three studies focused on postural control changes and loading in AIS patients. (Tarrant et al. … 2014, 1471-1477; Lonner et al. … 2014, 48S; Sarwahi et al. … 2014, E399-E405; De la Rocha, McClung & Sucato 2014, 208-213; Basques et al. … 2015, 286-294; Pasha et al. … 2015, 981-987; Carvalho de Abreu et al. … 2012, 886-590; Blondel et al. … 2012, 1964-1971.)

Tarrant et al and Lonner et al both studied the prevalence and timing at which AIS patients return to school or sports after their surgeries. They both found out that the overall prevalence is good. In the study group of Tarrant et al, 88,5% of the young patients had returned to contact or competitive sports at one-year time post-operation. Only 4,3% of the group did not return at all to sports due to chronic back pain. The equivalent number in the study group of Lonner et al was 95% of the patients returning to sports between six months to one year after the surgery. Only 5%

similarly did not return to sports. In Tarrant et al study over half (51,4%) of the patients could return to higher intensity sports, meaning competitive and contact sports, already at 6 months. In Lonner et al study, moderate intensity sports, including light swimming, jogging, pilates, were started after 3 months. This proves that physiotherapists should promote that it is common, safe and highly recommended to return back to physical activities. (Tarrant et al. … 2014, 1471-1477; Lonner et al. … 2014, 48S.)

In the study of Lonner et al, the interesting finding was the fact that although the return to old sports hobbies was common, the time spent and the intensity with which the young performed the sports had decreased compared to their pre-operative performance. The young themselves did not feel that their sports abilities had decreased due to the surgery. The physiotherapist could motivate the young to continue their sports hobbies as they used to and to find out what factors could be behind in the diminished amount spend at the sports hobbies. (Tarrant et al. … 2014, 1471-1477; Lonner et al. … 2014, 48S.)

Although the return to sports was relatively good in these two studies, there were some other problems concerning the patients' short-term functional ability. Tarrant et al studied that the majority of the patients returned to school full-time at 16 weeks postoperatively. This is rather late when it is compared with the guidelines and leaflets given to patients at the clinics, where the recommendation is only 4-6 weeks. Thus, the actual versus anticipated return differ widely. Also, a curve bigger than 70° combined with other surgical complications appeared to be a risk factor. Physiotherapists could via interview find out what are the subjective challenges of the patients in short term functional ability that could hinder them from returning back to school. (Tarrant et al. … 2014, 1471-1477; Lonner et al. … 2014, 48S.)

Sarwahi et al studied the total lung volume of postoperative AIS patients. They found out that the deformity correction leads only to the symmetry improvement of the thoracic architecture and joint mechanisms. It does not alter the total lung volume. In many studies it has been assumed, not proven, that AIS surgery increases total lung volume, which this study demonstrates to be incorrect. The problem appears to be a dynamic rather than a static problem. Physiotherapists could work on post-operative

dynamic breathing exercises such as deep expiration and inspiration involving movement from the chest and rib cage. (Sarwahi et al. … 2014, E399-E405.)

Two study groups, De la Rocha, McClung & Sucato and Basques et al studied the effect of high BMI scores and adverse events connected to obesity on patients after AIS operation. In De la Rocha et al study, the adolescents who were overweight reported to have worse scores in mental, activity level and appearance domain scores post-operatively compared with the normal weight or under weight adolescents. Interestingly the amount of correction was the same between the study groups and the obese patients exercised less than the other two groups. Basques et al found out that obesity stands as a risk for post-operative adverse events. This information may help the professional with preoperative counseling of overweight patients by stressing that their own assessment of outcome is influenced by BMI, which may help promote a healthy weight management program in this patient group. (De la Rocha, McClung & Sucato 2014, 208-213; Basques et al. … 2015, 286-294.)

The last three studies of Pasha et al, Carvalho de Abreu et al and Blondel et al, concentrated on the effects of spinal fusion on the postural changes and biomechanics on the spinal alignment. Pasha et al found out that the transfer load between spine and pelvis go through a lot of changes. There appears to be an increased amount of loading on sacrum after the fusion of the spine. Carvalho de Abreu et al studied that postural control changes are due to a sensorimotor impairment instead of biomechanical changes. Blondel et al proved that thoracic kyphosis correction improves lumbar lordosis and thus prevents the patient to have a flat lower back. This underlines the necessity to restore a natural thoracic kyphosis so that it is possible to also obtain a lumbar lordosis. Physiotherapists can work in these areas to help the AIS patients to restore a spine, which follows good biomechanical function and better postural control. (Pasha et al. … 2015, 981-987; Carvalho de Abreu et al. … 2012, 886-590; Blondel et al. … 2012, 1964-1971.)

8 CONCLUSION

The purpose of the review was to find out the post-operative challenges of AIS patients to which physiotherapy management would be necessary to after scoliosis surgery. The search process was successful: eight studies remained until the end. The studies focused on different aspects of postoperative management of scoliosis: the return to short-term function, the effects of obesity or increased BMI, the alteration in lung volume as well as postural changes and loading in AIS patients. The results showed multiple areas in which physiotherapy could be needed at.

The results proved that the patients' return to sports is likely but the intensity and the amount spent performing the sports had decreased. Also the return to school full-time happened later than expected. The professionals could find out what factors could be behind these findings and apply the needed therapy methods accordingly. It was also found out that spinal fusion offers only symmetrical improvement to the thoracic structures but does not increase lung volume itself. Dynamic breathing exercises could be applied to improve the lung volume and mobility of the chest area. One result showed that obesity stands as a risk for postoperative adverse events and decreased postoperative patient satisfaction. This could be prevented with preoperative physiotherapeutic counselling and a healthy weight management program. The postural changes are great in scoliosis surgery: the loading line of the body changes thus overloading sacrum and lower back. In addition there might be a sensorimotor problem leading to postural control problems. Restoring a natural thoracic kyphosis helps in obtaining a natural lumbar lordosis. Physiotherapists could offer their knowledge in restoring a functioning spine and help in improving postural control and correct biomechanical alignment of the spine. In short, there are a lot of areas in which physiotherapy management would be essential. (Tarrant et al. … 2014, 1471-1477; Lonner et al. … 2014, 48S; Sarwahi et al. … 2014, E399-E405; De la Rocha, McClung & Sucato 2014, 208-213; Basques et al. … 2015, 286-294; Pasha et al. … 2015, 981-987; Carvalho de Abreu et al. … 2012, 886-590; Blondel et al. … 2012, 1964-1971.)

9 DISCUSSION

The thesis process started in November 2014. Together with the thesis instructor, a possible client, Satakunta Central Hospital was contacted and asked for a thesis topic. A reply came soon after. Two topics were offered from which one of the topics was picked out based on my own interests. This lead to a meeting with a physiotherapist, Riikka Lempinen who works at the pediatric outpatient clinic. After discussing with her, slowly the thesis process began with brainstorming and planning.

In the beginning, the main idea of the thesis was to conduct a survey for young AIS patients who had gone through a scoliosis surgery within a year. The survey would have been a modified version of scoliosis research society's SRS-30 questionnaire. The focus would have been on post-operative satisfaction, self-image and the possible demand for an increased amount of physiotherapy consultation. The aim was to find out if the patients themselves felt a greater need for post-operative physiotherapy than they had been offered from Satakunta Central Hospital's behalf at that time. Due to permit allowances, this plan could not be carried out without making some bigger alterations suggested by the hospital staff. The deadline was getting nearer which was one of the main reasons why these alterations could not be carried out. Together with the tutoring teacher the future possibilities of the thesis were discussed. This resulted in the fact that the thesis study design was switched then into a literature review. This sudden and unexpected change was probably one of the biggest challenges in the whole thesis process.

The change in the study design meant that some work, which had been already done had to be left behind. Still, the switch happened surprisingly smoothly. The most important issue was the fact that the same thesis theory could be used regardless of the sudden change. Hardly any modifications had to be made on the theory itself. Writing the theory of this thesis went rather well. In June 2015, some literature and Internet references were collected from local libraries and Internet databases. The theory was written during the late summer and autumn of 2015.

The switch in the study design happened quite late in the thesis process, only in October, one month before the deadline. This meant that the pace at which the thesis had been written so far was not enough for reaching the goal, the deadline, on time. The pace had to be sped up. The literature review process was conducted in mid-October. Regardless of having a tighter schedule due to an overlap of the final clinical practice and writing the thesis, in the end I reached my goal and could finish the thesis exactly on time.

Conducting a literature review was a time-consuming yet an interesting process. It was a rich learning experience especially because it was the first literature review that I had to write. I had to familiarize myself with the whole concept of writing a literature review. The process was made easier with the consultation of the tutoring teacher, Mrs Maija Kangasperko and the University library staff. After this, the database search and the study selection were performed without any major difficulties. Gladly, there were surprisingly many articles, which passed the inclusion criteria.

The most challenging phase in writing the review was to write down the results of the eight studies that were included. The challenge laid partly in the fact that the studies focused on rather different areas. There was no common feature in all the remaining studies. It was surprisingly challenging to write down the results clearly when even the focus area of the studies varied so widely. As an author, I find that the conclusion of the thesis is not as impact as I would have wished for. I had a different vision of the results when deciding the study question. Perhaps the study question was not ideally formed or the exclusion criteria could have been even stricter leaving fewer studies to the final stage, which might have made the result of the literature review clearer and more reader-friendly.

Also, one of the biggest downsides of this thesis was the fact that no assessment of the studies was made. The studies were not randomized control trials (RCTs) or other studies with high level of evidence scores. PEDro-scaling (Physiotherapy Evidence Based Database scaling system) could not be used for other than RCT studies. This means that this thesis does not present as high evidence in its results as it could have, if only RCTs or other high-evidence studies had been used.

For further research, the thesis could be continued as it had been originally planned. A questionnaire could be conducted for the young AIS patients to find out their satisfaction after surgery, return to sports, their need for physiotherapy or some other key element of post-operative physiotherapy. One possible study topic, which stood up from the results, could be based on the fact that the young return to school much later than is proposed in the guidelines. The study could find out what are the reasons that hinder the postoperative patients from returning to school.

The results of this study work as a wide base for a further research with multiple interesting options to focus on. Because the AIS patients are under aged, very detailed and strict ethical aspects have to be taken into consideration in conducting the study. A permit from an ethical committee is needed for implementing such a study.

REFERENCES

Adams, J. C. & Hamblen, D. L. 2001. Outline of Orthopaedics, 13th edition. London: Churhill Livingstone.

Agur, A. & Dalley, A. 2012. Grant's Atlas of Anatomy, 13th edition. Lippincott Williams & Wilkins.

Basques B. A., Bohl, D. D., Golinvaux, N. S., Smith, B. G. & Grauer, J. N. 2014. Patient Factors are Associated With Poor Short-term Outcomes After Posterior Fusion for Adolescent Idiopathic Scoliosis. Clinical Orthopaedics and Related Researches(2015) 473;286-294.

Blondel, B., Lafage, V., Schwab, F., Farcy, J. P., Bollini, G. & Jouve, J. L. Sagittal Alignment Changes After Posterior Fusion in the Setting of Adolescent Idiopathic Scoliosis. European Spine Journal 2012 Oct; 21(10): 1964–1971.

Buttermann, G. L. & Mueller, S. A. 2015. Surgery Outcomes of Adolescent Idiopathic Scoliosis Surgery Related to Age and Length of Follow-up. The Spine Journal 2015, 7, 162.

Carvalho de Abreu, D. C,. Gomes, M. M., Rocha de Santiago, H. A., Pereira da Silva Herrero, C. F., Porto, M. A & Defino, H. L. A. 2012. What is the Influence of Surgical Treatment Of Adolescent Idiopathic Scoliosis on Postural Control? Gait & Posture 36 (2012) 586-590.

Chan, C. Y. W., Kwan, M. K., Saw, L. B., Deepak, A. S., Chong, C. S., Liew, T. M. & Lee, C. S. 2008. Post-operative Health Related Quality of Life Assessment in Scoliosis Patients. Med J Malaysia No2, 137-139.

Crowther, C. L. 1999. Primary Orthopedic Care. USA: Mosby.

Haher, T., Gorup, M., Shin, T., Homel, P., Merola, A., Grogan, D., Pugh, L., Lowe, T. & Murray, M. 1999. Results of the Scoliosis Research Society Instrument for Evaluation of Surgical Outcome in Adolescent Idiopathic Scoliosis: A Multicenter Study of 244 Patients. Spinejournal vol 24, issue 14, 1435.

Hakkarainen, H. 2007. Nuoruusiän idiopaattinen skolioosi: itseopiskelumateriaali fysioterapeuttiopiskelijoille. Thesis. Helsinki: Stadia. Helsingin ammattikorkeakoulu.

Han, J., Xu, Q., Yang, Y., Yao, Z. & Zhang, C. 2015. Evaluation of quality of life and risk factors affecting quality of life and risk factors affecting quality of life in adolescent idiopathic scoliosis. Intractable Rare Diseases Research 4, 12-16.

Hartikainen, S. 2004. Ortopedia. Lasten ja nuorten hoitotyon kasikirja. Tammi, Jyväskyla.

Helenius, I. & Pajulo, O. 2015. Vaikean skolioosin hoito. Lääketieteellinen Aikakauslehti Duodecim 131(19):1785-91. Referred 13.10.2015 http://www.terveysportti.fi.lillukka.samk.fi/dtk/ltk/koti?p_artikkeli=duo12461&p_haku=skolioosi

Helenius, I. 2013. Anterior surgery for adolescent idiopathic scoliosis. Journal of Children's Orthopaedics 7, 63-68.

Helenius I. 2009. Kasvuikäisen selkäongelmien kirurginen hoito. Journal of Duodecim 11, 1168-1175. Referred 30.6.2015. http://www.terveysportti.fi/xmedia/duo/duo98098.pdf

Helenius, I. & Parkkila, T. 2008. Varhaislapsuuden skolioosin vanhat ja uudet hoitomenetelmat. Lääketieteellinen aikakausikirja Duodecim 124 (22). 2541– 46.

Helenius, I. 2015. Skolioosi. Lääkärikirja Duodecim. Referred 18.9.2015. http://www.terveyskirjasto.fi/terveyskirjasto/tk.koti?p_artikkeli=dlk00836&p_haku=selän%20virheasen%2a

Horne, J. P., Flannery, R. & Usman, S. 2014. Adolscent Idiopathic Scoliosis: Diagnosis and Management. American Family Physician 1, 193-198. Referred 15.9.2015. http://www.aafp.org/afp/2014/0201/p193.html

Johansson, K., Axelin, A., Stolt, M. & Ääri, R-L. 2007. Systemaattinen kirjallisuuskatsaus ja sen tekeminen. Turku: Turun Yliopisto.

Kerttula, L., Schlenzka, D. & Tallroth, K. 2004. Skolioosin kuvantaminen. Lääketieteellinen aikakauskirja Duodecim 120(19):2298-305. Referred 13.10.2015. http://www.terveysportti.fi.lillukka.samk.fi/dtk/ltk/koti?p_artikkeli=duo94541&p_haku=skolioosi

Lempinen, R. Fysioterapeutti. 2014 & 2015. Interview. Interviewer Ahola, J. Pori.

Lonner , B. S., Ren, Y., Rieger, M., Petrizzo, A., Rogers, P. & Toombs, C. 2014. Level of Play: Return to Sports Following Surgery for Adolescent Idiopathic Scoliosis. The Spine Journal. 8, 126.

Magee, D. J. 2008. Orthopedic Physical Assessment, 5th Edition. Canada: Saunders.

Nissinen, M. 1996. The Growth of the Adolescent Back. A three year cohort study. Helsinki: University of Helsinki.

Nissinen, M., Heliovaara, M., Ylikoski, M. & Poussa, M. Trunk asymmetry and screening for scoliosis: a longitudinal cohort study of pubertal schoolchildren. Acta Pediatr 1993;82:77–82.

Pasha, S., Aubin, C-E., Labelle, H., Parent, S. & Mac-Thiong, J-M. 2015. The Biomechanical Effects of Spinal Fusion on the Sacral Loading in Adolescent Idiopathic Scoliosis. Journal of Clinical Biomechanics 30, 981-987.

Pihlajamäki, S. & Ruuska, A. 2010. Mutkat suoriksi: Selvitystyö lapsuus- ja nuoruusiän idiopaattisen skolioosin hoitokäytänteistä Suomessa. Thesis. Helsinki: Metropolia Ammattikorkeakoulu. Referred 30.6.2015.

Romano, M., Negrini, A., Parzini, S., Tavernaro, M., Zaina, F., Donzelli, S. & Negrini. S. 2015. SEAS (Scientific Exercises Approach to Scoliosis): a modern and effective evidence based approach to physiotherapy specific scoliosis exercises. Journal of Scoliosis 10, 3. Referred 15.9.2015. http://www.ncbi.nlm.nih.gov

Ryöppy, S. 1997. Lasten Ortopedia. Jyväskylä: Gummerus Kirjapaino.

Sarwahi, V., Sugarman, E. P., Wollowick, A. L., Amaral, T. D., Harmon, E. D. & Thornhill, B. 2014. Scoliosis Surgery in Patients With Adolescent Idiopathic Scoliosis Does Not Alter Lung Volume. The Journal of Spine Vol. 39, 6, pp. E399-E405.

Tarrant, R. C., O'Loughlin P. F., Lynch, S. Queally, J. M., Sheeran, P., Moore, D. P. & Kiely, P. J. 2012. Timing and Predictors of Return to Short-term Functional Activity in Adolescent Idiopathic Scoliosis After Posterior Spinal Fusion. Journal of Spine. Vol 39, 18, pp.1471-1478.

Tortora, G. & Derrickson, B. 2011. Principles of Anatomy and Physiology, 13th edition. John Wiley & Sons, Inc.

Vartiainen, A. & Ylipukki, J. 2010. Skolioosileikkauksesta toipuva nuori sairaalahoidossa. Thesis. Oulu: Oulun seudun ammattikorkeakoulu.

Website of the Scoliosis Research Society. Referred 19.8.2015. http://www.srs.org

Website of American Family Physician. Referred 15.9.2015. http://www.aafp.org

Website of Chiropractic Specialty Center. Referred 15.9.2015. http://www.mychiro.com.my

Website of Bethesda Clinic. Referred 15.9.2015. http://www.bethesda-clinic.com

Website of the Free Dictionary. Referred 15.9.2015. http://medical-dictionary.thefreedictionary.com

Website of Broadway Chiropratctic and Wellness Center New York. Referred 17.7.2015. http://www.bcwnyc.com

Website of Orthotics Prosthesis New England. Referred 16.9.2015. http://www.orthoticsprostheticsne.com/home/pediatric-orthotics/scoliosis

Website of Posturetek. Referred 16.9.2015. http://www.posturetek.com/en/scoliosis.html

Website of Virginia Spine Institute. 2015. Referred 15.10.2015. http://www.spinemd.com/symptoms-conditions/congenital-scoliosis

Website of Spinal Universe 2015. Referred 15.10.2015. http://www.spineuniverse.com/anatomy

Website of Scoliosisjournal 2015. Referred 1.11.2015. http://www.scoliosisjournal.com/content/supplementary/1748-7161-7-1-s3.pdf

Website of Evidence based practice wikispaces 2015. Referred 1.11.2015 https://evidence-based-practice.wikispaces.com

Website of American Speech-Language-Hearing Association 2015. Referred 1.11.2015. http://www.asha.org/members/ebp/

Website of UW medicine, Department of Scoliosis 2015. Referred 6.11.2015. http://www.rad.washington.edu

Weinstein, S. L. 2001. The Pediatric Spine: Principles and Practice, 2nd Edition. USA: Lippincott Williams & Wilkins

APPENDIX 1. Thesis process.

November 2014	Finding a thesis topic
December 2014	Meeting the representative of Satakunta central hospital
February 2015 – May 2015	Clinical practice abroad
June 2015	A new meeting at the hospital, gathering references
August 2015	Beginning to write theory
September 2015	Writing theory and applying for permission from ethical committee
October 2015	Sudden change in the research method: from a questionnaire into a systematic review, writing theory.
November 2015	Finalizing thesis and the presentation seminar