

Is There a Relationship Between Dominant Arm and Major Thoracic Curve Direction in Adolescent Idiopathic Scoliosis? A Single-Center Retrospective Study

Adölesan İdiyopatik Skolyozda Dominant Kol ve Major Torasik Eğri Arasında İlişki Var Mıdır? Tek Merkezli Retrospektif Araştırma

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ABSTRACT

Objective: This study aims to examine the correlation between significant thoracic curvature and the dominant arm side in patients diagnosed with adolescent idiopathic scoliosis, a contentious issue in the scientific literature, and to communicate the findings to the scientific community.

Method: This retrospective study included patients diagnosed with adolescent idiopathic scoliosis aged between 10 and 19 years, with a major thoracic curve. The patients' age, Cobb angle from the latest X-ray and direction of thoracic curve, and dominant upper extremity were recorded and evaluated.

Results: The study included 50 participants in total who satisfied the inclusion criteria. However, due to his statement that he used both his right and left hands equally, a male patient, age 15, was not included in the analyses. The mean age of the patients was 14.7 years and mean Cobb angle was 29.5. Forty-one patients had right thoracic curvature, while eight patients had left thoracic curvature. Only two patients had left extremity dominance. There was no statistically significant difference in the direction of dominant extremity between the right and left thoracic curve patterns ($p=0.377$).

Conclusion: According to the results of our study, no relationship was found between the direction of the thoracic curve and upper extremity dominance. However, future studies with larger sample sizes, including different curve patterns, and investigating the effect of brain lateralization are needed.

Keywords: Adolescence, Handedness, Laterality, Scoliosis, Spine

Öz

Amaç: Bu çalışmanın amacı, bilimsel literatürde tartışmalı bir konu olan ergen idiyopatik skolyoz tanısı almış hastalarda majör torasik eğrilik ile dominant kol taraf arasındaki ilişkiyi incelemek ve bulguları bilimsel literatüre sunmaktır.

Yöntem: Bu retrospektif çalışmaya, 10 ila 19 yaşları arasında, majör torasik eğriliği olan ergen idiyopatik skolyoz tanısı almış hastalar dahil edildi. Hastaların yaşı, son röntgendeki Cobb açısı ve torasik eğrinin yönü ve dominant üst ekstremitesi kaydedildi ve değerlendirildi.

Çalışmaya, dahil etme kriterlerini karşılayan toplam 50 katılımcı dahil edildi. Ancak, hem sağ hem de sol elini eşit şekilde kullandığını ifade ettiği için, 15 yaşında bir erkek hasta analizlere dahil edilmedi. Hastaların ortalama yaşı 14,7 yıl ve ortalama Cobb açısı 29,5 olarak bulundu. Kırk bir hastada sağ torasik eğrilik, sekiz hastada ise sol torasik eğrilik vardı. Sadece iki hastada sol ekstremitede hakimiyeti vardı. Sağ ve sol torasik eğri paternleri arasında dominant ekstremitede yönünde istatistiksel olarak anlamlı bir fark yoktu ($p=0,377$).

Sonuç: Çalışmamızın sonuçlarına göre torasik eğrinin yönü ile üst ekstremitede hakimiyeti arasında bir ilişki bulunmadı. Ancak daha büyük örneklem büyüklüklerine sahip, farklı eğri paternlerini içeren ve beyin lateralizasyonunun etkisini araştıran gelecekteki çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Adölesan, El tercihi, Lateralite, Skolyoz, Omurga

1. INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a three-dimensional deformity characterized by a lateral curvature of the spine greater than 10°, rotation, and changes in the sagittal plane. Although multiple theories and causes have been proposed regarding the etiology of AIS, its exact cause has not yet been clearly identified (Chik, 2020).

Although right thoracic curves are found to be much more common than left thoracic curves in AIS, their exact cause has not yet been determined (Chik, 2020; Deetjen et al., 2011). It has long been debated that anatomical factors, such as the asymmetric positions of the heart and aorta, along with dominant hand use, may influence the development of AIS and affect the location of the curve pattern (Goldberg & Dowling, 1990; RW, 1985; Taylor, 1986).

The marked predominance of right convex thoracic curve patterns in scoliosis has always suggested a parallel with hand preference and other patterns of cerebral lateralization. This has led to two hypotheses: either handedness is the cause of scoliosis, or conversely, scoliosis determines handedness (Goldberg & Dowling, 1990; Grivas et al., 2006; Miles, 1944). Left-handedness tends to be interpreted as abnormal and pathological to some extent, potentially associated with certain adverse effects, while left convex scoliosis (RW, 1985) (Wu et al., 2010) has been perceived as an indicator of an underlying pathology.

In studies conducted on school screening populations, generally with mild or minimal curvature (Goldberg & Dowling, 1990; Goldberg & Dowling, 1991), a normal distribution of handedness (10% left-handed (Porac & Coren, 1979) was observed. A correlation between hand preference and scoliosis patterns, as well as certain associations with the scoliosis pattern of patients, was identified.

In an editorial letter, Jansen et al. reported that the asymmetric positions of organs might lead to vertebral rotation during skeletal formation and thus influence the development and location of scoliosis, while no association with dominant hand use was found (Kouwenhoven et al., 2011). A study conducted on 550 individuals found that only 2.8% had left-curving scoliosis (Ellis et al., 1971). Similarly, a British Broadcasting Corporation (BBC) online survey with 255,100 participants reported that 7–11.8% of respondents were left-hand dominant (Peters et al., 2006).

In a study published by Goldberg and Dowling in 1991, when examining two separate groups consisting of right – and left-handed individuals, they reported a significant relationship between the dominant hand side and body asymmetry (Goldberg & Dowling, 1991). Milenkovic et al. conducted a study investigating the frequency of scoliosis and hyperkyphosis in relation to handedness and found a significant relationship between dominant left-handedness and the frequency of these conditions. However, no information was provided regarding the location of scoliosis in this study (Milenkovic et al., 2004). Another study involving 8245 children in a school

screening investigated the relationship between body rotation and dominant hand, suggesting a possible link between hand dominance and body rotation (Grivas et al., 2006). However, the researchers in this study did not apply radiographic evaluation or advanced examination techniques for diagnostic or differential diagnosis in children with asymmetry detected by body rotation measurements. Another important point is that existing studies in the literature have not included other juvenile and neuromuscular scolioses, as well as other spinal deformities such as hyperkyphosis, making their evaluation incomplete.

The aim of this study is to investigate the relationship between major thoracic curvature and the dominant side arm in patients diagnosed with adolescent idiopathic scoliosis, a still debated issue in the literature, and to present the findings to the scientific community.

2. MATERIALS AND METHODS

The study was approved by the Non-Interventional Ethics Committee of the Faculty of Health Sciences, Marmara University, and was conducted in accordance with the Declaration of Helsinki.

In this study, the records of individuals aged 10-19 diagnosed with scoliosis who applied to Dr. Cagatay Uluçay orthopedics and traumatology clinic between 2020 and 2024 were retrospectively reviewed. Patients aged 10-19 with a Cobb angle >10° and a diagnosed thoracic major curve of idiopathic origin were included. Those with lumbar-only or double thoracic curves, scoliosis due to causes other than idiopathic, or those with other orthopedic, neurological, or congenital problems (e.g., brachial plexus injury, hemiparesis) were excluded from the study.

Information routinely recorded in the patient files regarding the degree and location of the major curve and the use of the dominant extremity was collected.

The degree of the curve was assessed on the patient's final anteroposterior radiograph using the Cobb method (Cobb, 1948). The evaluation of scoliosis severity with the Cobb angle is still considered the gold standard today (Moramarco et al., 2020). To measure the Cobb angle, the most superior and inferior vertebrae involved in the curve were identified. Lines were drawn along the endplates of these vertebrae, and these lines were connected by two perpendicular lines. The angle between these lines was measured and recorded (Cobb, 1948). The direction of the thoracic major curve was determined and recorded based on the location of the convex side on the final radiograph (Moramarco et al., 2020).

The advantage of one side of the body in terms of coordination, accuracy, and usability is known as laterality (Bondi et al., 2020). The development of lateral preference continues to progress throughout childhood and generally achieves its completeness by the age of 7 (Bondi et al., 2020).

To determine the dominant upper extremity of the patients, they were asked which hand they used for eating and writing, and this information was recorded. Each child was classified as having either right or left extremity dominance (Arienti et al., 2019; Grivas et al., 2006).

The patients' information was transferred from the files to a computer and analyzed using SPSS version 16. Continuous variables were presented as mean $\pm$ standard deviation, median (minimum-maximum), while categorical variables were presented as count and percentage (%). The Chi-square test was used to compare categorical variables between groups.

3. RESULTS

A total of 129 patient files were reviewed. A total of 50 individuals who met the inclusion criteria were included in the study. A 15-year-old male patient was excluded from the analyses because he stated that he used both his right and left hands equally. The overall average age was 14.7 years. The mean Cobb angles were 29.5 (Table 1). The majority of the patients had a right-dominant extremity, and similarly, the majority had a right thoracic curve. The majority of patients with left thoracic curvature also had right upper extremity dominance (Table 1, Graphic 1).

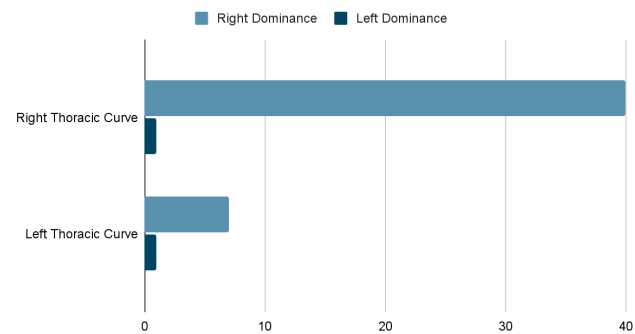
Table 1: Clinical evaluations of the patients

	Total n=49 Mean $\pm$ SD (Min – Max) / Frequency (n%)	Right dominant n=47 Mean $\pm$ SD (Min – Max) / Frequency (n%)	Left dominant n=2 Mean $\pm$ SD (Min – Max) / Frequency (n%)
Gender	Female 39 (75%) Male 10 (25%)	Female 38 (80.9%) Male 9 (19.1%)	Female 1 (50%) Male 1 (50%)
Direction of the thoracic curve	Right 41 (80.5%) Left 8 (19.5%)	Right 40 (85.1%) Left 7 (14.9%)	Right 1 (50%) Left 1 (50%)
Age (years)	14.7 $\pm$ 2.2 (11 – 19)	14.7 $\pm$ 2.3 (11 – 19)	15 $\pm$ 1.4 (14 – 16)
Maksimum Cobb Angle (°)	29.5 $\pm$ 11.8 (12 – 60)	29.8 $\pm$ 11.9 (12 – 60)	24 $\pm$ 5.6 (20 – 28)

SD: standart deviation; min: minimum; max: maximum

When the relationship between the dominant extremity and the direction of the curve was analyzed using the Chi-square test, it was determined that most patients with both right and left thoracic curves had a dominant right extremity. However, there was no statistically significant difference in the distribution of dominant extremity direction between the groups ($p=0.377$).

Curve Direction and Extremity Dominance



Graphic 1: Distribution of dominant hand preference based on the direction of the thoracic curve (right or left).

Right dominance was observed in 94% of cases with right curves and 87.5% of cases with left curves.

4. DISCUSSIONS AND CONCLUSION

This study retrospectively analyzed the relationship between hand dominance and major thoracic curves in adolescent idiopathic scoliosis patients. According to the results of our study, most of the patients were right-dominant. In the majority of patients, the convex side of the thoracic curve was on the right. Only one left-dominant patient had a left thoracic curve. In our study, 87.5% of individuals with left thoracic curvature were right upper extremity dominant, indicating no relationship between the dominant extremity and the direction of the curve.

Lateralization, referring to the dominance of one side of the body or brain, is not exclusively a human trait. It has been observed in various species, such as rats, chimpanzees, dogs, birds, some fish, and lizards. In humans, hand dominance is the most evident example of lateralization, showcasing a preference for one hand in performing complex psychomotor tasks. This is tied to additional cerebral support, granting the dominant hand greater dexterity and capability. While the asymmetry of brain organization has been confirmed in many vertebrates, the relationship between hand dominance and brain structure and function in humans remains unclear (Milenković et al., 2016; Sainburg, 2014).

In the literature, a meta-analysis study including 2,396,170 individuals shows that the best estimate for the prevalence of left-handedness is 10.6% (9.3% – 18.1%). Additionally, the best estimate for the prevalence of mixed-handedness is 9.33%, a figure almost as high as that of left-handedness (Papadatou-Pastou et al., 2020). In this study, only one male patient reported using both hands equally, while 2 patients were left-handed dominant.

Yang and Li argue that the right-left handedness mechanism is related to intrinsic and extrinsic muscle strength. Therefore, they state that right handedness, especially in the second growth spurt (adolescence), may affect spinal flexion and rotation, and that there may be a relationship between right thoracic curves and right handedness (Li, 2011). In addition,

researchers stated that left handedness would not have an effect on the direction of spinal curvature and that the location of the thoracic curve could be seen randomly (Li, 2011). Our findings align with Li et al. (2011), who suggested that left-handedness may not consistently affect spinal curvature patterns. This variability in curve direction warrants further investigation into other biomechanical factors.

An old study found a positive correlation between dominant hand use and scoliosis configuration (Goldberg & Dowling, 1990), no clear correlation was found in the relationship with trunk lateralization (Burwell et al., 1983; Grivas et al., 2006). Grivas et al. reported that 1451 participants had right thoracic asymmetry and 832 participants had left thoracic asymmetry in their study with 8245 participants aged 6-18 (Grivas et al., 2006). In this study, where they measured trunk asymmetry with a scoliometer, they associated individuals with 7° and above scoliometric measurements with the presence of scoliosis and the risk of developing scoliosis due to their severe asymmetry (Prujns et al., 1992). When the group associated with scoliosis was examined, it was reported that 103 participants had right asymmetry and 36 had left asymmetry. Right dominant hand use was reported in 94 children with severe right thoracic trunk asymmetry and 34 children with left thoracic trunk asymmetry. No significant correlation was found between individuals with suspected scoliosis and the dominant hand, but a positive correlation was found between dominant hand use and the location of trunk asymmetry in the presence of asymmetry that could cause spinal deformity between 2° and 7° (Grivas et al., 2006). However, it should be noted that the methodologies and age groups included in the studies differ. For example, Grivas and colleagues (Grivas et al., 2006) used only a scoliometer for assessment in their study. In such an evaluation, double thoracic curves or congenital curves may have been overlooked.

A previous study found that individuals with right thoracic AIS exhibited a significantly higher frequency of crossed eye-hand laterality compared to the sex and age-matched control group (63% vs. 29.2%). The study also reported that the most common pattern of crossed laterality in the AIS group was "right hand dominant-left eye dominant," observed in 82.9% of cases (Catanzariti et al., 2014). However, since eye dominance was not evaluated in our study, a comparison could not be made.

In response to these studies, Arienti and colleagues reported that left-side dominance could have a prevalence on trunk asymmetry in thoracic and thoraco-lumbar curves (Arienti et al., 2019). In the current study, there were only two patients with left upper extremity dominance. Therefore, our findings were not similar to those of this research.

There are very limited studies investigating whether extremity dominance is a factor in scoliosis or if it affects the direction of the curve. In this sense, we believe that our study will contribute to the literature. However, the small sample size of our study and its single-center design can be considered as limitations.

This study found no statistically significant association between thoracic curve direction and hand dominance; however, this topic remains controversial in the literature, and much more comprehensive studies with larger sample sizes, including different curve patterns are needed.

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