Subjective visual vertical in patients with idiopathic scoliosis

Ondřej Čakrt\textsuperscript{a,b,*}, Kryštof Slaby\textsuperscript{a}, Lucie Viktorinová\textsuperscript{a}, Pavel Kolár\textsuperscript{a} and Jaroslav Jeřábek\textsuperscript{b,c}

\textsuperscript{a}Department of Rehabilitation and Sports Medicine, 2nd Faculty of Medicine, Faculty Hospital Motol, Charles University, Prague, Czech Republic
\textsuperscript{b}Faculty of Biomedical Engineering, Czech Technical University, Prague, Czech Republic
\textsuperscript{c}Department of Neurology, 2nd Faculty of Medicine, Faculty Hospital Motol, Charles University, Prague, Czech Republic

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Abstract. Idiopathic scoliosis (IS) is characterized by a three-dimensional deviation of the vertebral column and its etiopathogenesis is unknown. Various factors are associated with idiopathic scoliosis, among these a prominent role has been attributed to integration of vestibular information with graviception for perception of space. Subjective visual vertical (SVV) is a sensitive sign of verticality perception. The aim of this study was to determine if SVV in adolescents with IS is different from healthy controls. Examination of SVV was performed using the bucket method. Binocular measurements of SVV were made in 23 adolescents with IS (age 14.5 \(\pm\) 2.5, mean \(\pm\) SD) and 23 healthy subjects (age 14.0 \(\pm\) 2.9). The groups differed significantly on SVV deviation (\(p < 0.01\)): healthy controls (\(-0.04 \,^\circ\) \(\pm\) 0.64 \(^\circ\)), IS group (0.86 \(^\circ\) \(\pm\) 1.39 \(^\circ\)). There was also significant difference in SVV uncertainty (\(p < 0.001\)): healthy controls (1.50 \(^\circ\) \(\pm\) 0.94 \(^\circ\)), IS group (2.46 \(\pm\) 0.82 \(^\circ\)). We conclude that the perception of visual vertical is altered in IS which may play role in development of IS.

Keywords: Scoliosis, adolescent, vestibular function, otolith system, bucket method

1. Introduction

Scoliosis is a 3-dimensional deformity of the spine characterized by deformation in the sagittal (thoracic lordosis), frontal (lateral curvature) and transverse planes (vertebral rotation). Idiopathic scoliosis (IS) is the most common type of spine deformity. Its prevalence is about 2\% to 3\% in children aged 10 to 16 years. Girls are at a higher risk than boys for severe progression [12]. Although the etiopathogenesis of scoliosis is unknown, various factors have been identified that could be related to the etiology of scoliosis.

Abnormalities in postural control, vestibular and somatosensory function have been described in patients with IS [11,21]. Erect standing posture can be compromised by “lateropulsion”, that is an active lateral tilt of the body [5,20]. Lateropulsion could be an attempt to align the body with an internal vertical reference which is erroneously perceived to be tilted from true earth vertical [9,19] which is also sensed by somaesthetic graviception [2]. Vestibular dysfunction is compatible with imbalance of the activity in central vestibular neurons [18]. A tilt of the subjective visual vertical (SVV) is a sensitive sign of vestibular tone imbalance [6,7,10]. It can result from lesions of central and peripheral vestibular pathways. Standard testing methods for SVV (i.e. the hemispheric dome method and light bar in the dark method) are still adopted mainly by specialized departments [4]. The equipment is large and not easily moved and the cost may limit its use in many clinical
environments. A practical and reliable bedside tool for determining the SVV is the bucket method described by Zwergal et al. [23]. Our aim was to determine if SVV measured with the bucket method is different in patients with idiopathic scoliosis and healthy controls.

2. Methods

2.1. Subjects

Twenty-three patients (18 girls and 5 boys) with idiopathic scoliosis aged 8–18 years (14.5 ± 2.5, mean ± standard deviation) participated in the study. The board-certified pediatric orthopedist had previously screened and diagnosed IS. All patients were recruited from the orthopedic care unit at the Faculty Hospital Motol, Czech Republic. None of the patients had surgery before and no patient presented any pathology in neurologic examination. All patients were examined with X-rays with the antero-posterior view of the whole spine. The average Cobb angle was 21.4° ± 8.8° and varied between 11° and 36°.

The control subjects were recruited from the students at a local school and consisted of 23 age-matched and sex-matched healthy adolescents (mean age 14.0 ± 2.9, 18 girls and 5 boys). No participant reported any neurologic or orthopedic problems. All of them were screened for scoliosis by an experienced physiotherapist. Subject characteristics including description of scoliosis pattern are listed in Table 1.

Parents, and also adolescents gave their informed consent before the experiment. The study was performed in accordance with the Helsinki Declaration. The study protocol was approved by the local ethical committee.

2.2. Apparatus and testing procedures

Patients were examined in the period from April 2009 to December 2009. Examinations took place at the Department of Rehabilitation, 2nd Faculty of Medicine, Charles University, Prague. Subjects in the control group were examined in December 2009 in their school. Both groups were examined by the same experienced physiotherapist using the uniform testing protocol.

Examination of the SVV was performed using the bucket method described by Zwergal and coworkers [23]. Subjects stood upright and looked into a plastic, opaque bucket. The position of the subject’s head was not fixed in the frame. The subject could not see beyond the rim of the bucket, providing no cues to visual orientation. On the bottom outside there was a perpendicular line originating from center point of a quadrant divided into degrees with the zero line adjusted to the dark line inside (See Fig. 1). On each trial the examiner randomly rotated the bucket right or left to various end positions. Then the examiner slowly rotated the bucket until the subject signaled that the inside bottom line was vertical by saying “stop”. Subjects performed 10 trials, 5 trials clockwise and 5 counterclockwise. Degrees were read off on the outside scale by the examiner. Measurements were made binocularly, i.e. with both eyes open. Time needed for examination was approximately 5 minutes.

The deviation of SVV from true spatial vertical was computed for each participant as an average of all 10 measurements. We also computed SVV uncertainty as difference between the average SVV deviation of clockwise and counterclockwise measurements. All of the parameters for both groups were expressed as mean ± SD. We also compared data from our control group with the original control group from Zwergal’s paper [23] that they provided as a supplement.

<table>
<thead>
<tr>
<th>Subjects’ characteristics</th>
<th>Patients</th>
<th>Control</th>
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</thead>
<tbody>
<tr>
<td>N</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>boys/girls</td>
<td>5/18</td>
<td>5/18</td>
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<tr>
<td>Age [years]</td>
<td>14.5 ± 2.5</td>
<td>14.0 ± 2.9</td>
</tr>
<tr>
<td>Cobb angle [°]</td>
<td>21.4 ± 8.8</td>
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<tr>
<td>Scoliosis type</td>
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<tr>
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<tr>
<td>Right thoraco-lumbar</td>
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</tr>
<tr>
<td>Left thoraco-lumbar</td>
<td>9</td>
<td>NA</td>
</tr>
</tbody>
</table>
3. Results

Our IS group and our control group did not differ in the mean age or sex ratio. The groups differed significantly on SVV deviation (p < 0.01): healthy controls −0.04° ± 0.64°, IS group 0.86° ± 1.39°. See Fig. 2. There was also a significant difference in SVV uncertainty (p < 0.001): healthy controls 1.50° ± 0.94°, IS group 2.46° ± 0.82°. See Fig. 3.

Comparison of SVV deviation between our control group and the control group in Zwergal’s paper did not show significant differences: our controls −0.04° ± 0.64°, Zwergal’s controls 0.28° ± 1.15°. See Fig. 4.

4. Discussion

The main finding is that patients with IS have abnormal SVV perception. This study showed that these patients differed significantly in SVV deviation and SVV uncertainty from age- and sex-matched healthy subjects. SVV is a sensitive sign of verticality perception that relies on visual and vestibular information and it is the most sensitive sign of vestibular tone imbalance in the roll plane [1,10]. It can result from lesions of central and peripheral vestibular pathways. Therefore, these results support hypothesis that patients with IS might have some imbalance in central or peripheral vestibular pathways.

Our results are supported by earlier experiments with animals and children [3,17]. A study in adult guinea pigs showed that selective experimental lesions of the otolith receptors induce deformations of the spine comparable in many ways to those observed in children with IS [8]. Wiener-Vacher and Mazda studied otolith vestibular function in 30 children with IS, using off-vertical axis rotation (OVAR). Of the patients, 67% had significantly greater values of directional preponderance on the OVAR test compared with control subjects [22].

We used the bucket method as a simple bedside test for SVV. Healthy subjects could adjust their SVV to true vertical within a mean error of < 2°. This ability depends primarily on vestibular cues [5]. Our subjects stood upright during examination but their heads were not fixed with the external frame. In this case SVV could be influenced also by head and body position (so
called E-effect) [13]. On the other hand, subjects held their spontaneous posture in which they sense SVV in everyday’s life.

The average deviations of SVV in our group were significantly larger than those in control group. More than 20% of patients with IS showed deviation more than 2° in average of all 10 measurements. In the light of this observation, it is possible that a functional asymmetry or disturbance at some level in the vestibulospinal reflex, in the labyrinth or in vestibular pathway in the brainstem, might be a contributory mechanism of IS. This hypothesis may be further supported by the significantly greater uncertainty of SVV perception.

Comparison of SVV between our control group and the control group in Zwergal’s paper showed no significant differences despite different ages. The evidence on aging of SVV is not fully conclusive but it seems that there is no [16] or very small [14] increase in deviation of SVV in adults up to age of approximately 65 years. Data from controls in both studies fell well within the reference range [15].

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References


![Fig. 4. Comparison of SVV deviation in control group from Zwergal's paper [23] with our healthy controls.](image-url)

