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Effect of a spinal brace on postural control in different sensory conditions in adolescent idiopathic scoliosis: A preliminary analysis

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ABSTRACT

Background: Despite the positive effects of spinal braces on postural stability, they may constrain movement, resulting in poor balance control in patients with adolescent idiopathic scoliosis (AIS). Therefore, assessment of postural dynamics may aid in designing new less-constraining braces.
Objectives: The effects of a spinal brace on postural stability and Cobb angle were investigated in this study.
Methods: Thirteen pediatric patients (10 females, three males) with AIS were recruited to participate in the study. Cobb angle was assessed by X-ray analyses, and postural stability was tested by computerized dynamic posturography in braced and unbraced conditions. A polyethylene underarm corrective spinal brace was fabricated for the subjects.
Results: Thoracic and lumbar curvature decreased to $18.88 \pm 11.73^\circ$ and $17.70 \pm 10.58^\circ$, respectively, after bracing ($p < 0.05$). Lower equilibrium scores were observed in the "eyes closed" condition and higher scores in the "eyes closed with a swaying support" condition; higher composite equilibrium scores were also observed for the sensory organization test ($p < 0.05$) in the braced condition. Lower scores were observed for the "toes-up adaptation test" in the braced condition ($p < 0.05$). In the braced condition, the reaction time was slower in the right-backward direction and movement velocity was higher in the right-front direction on the limits of stability test ($p < 0.05$). Furthermore, lower on-axis velocity during forward/backward dynamic balance control was observed in the braced condition ($p < 0.05$).
Conclusions: Wearing a spinal brace improved postural stability in terms of increased proprioception, equilibrium performance, and rhythmic movement ability in patients with AIS.

1. Introduction

Various methods of rehabilitation have been utilized for patients with adolescent idiopathic scoliosis (AIS) to decrease curve progression [1–5]. One of these is spinal orthotic treatment [6,7], has been recommended in skeletally immature patients [1] with curvatures ranging from 25° to 45° [8]. Several types of spinal braces are commonly used in patients with AIS [9,10], and differ in impact based on individual design characteristics and underlying mechanisms of preventing curve progression.

Most commonly used concepts of spinal braces include Cheneau concept, SPoRT concept and Boston brace systems which have different external corrective force application techniques by using rigid, semi-rigid supports or elastic bands and daily brace wear durations. Cheneau concept braces depend on overcorrection (asymmetrical correction) of three-dimensional scoliotic deformity as lateral deviation on frontal plane, torsion of certain spine parts producing the rib hump or lumbar hump on horizontal plane and deterioration of the thoracic kyphosis and lumbar lordosis on sagittal plane [11]. The SPoRT concept including Sibilla and

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Sforzesco braces is a symmetrical, patient-oriented, rigid, three-dimensional, active and custom-made concept [12] whereas, Boston braces have fabricated design and antilordotic and antirotative effects as well [13]. Studies have shown that individual braces may prevent curve progression but also can achieve some curve correction [2,3,10,12–14].

Recently, many studies have investigated the effects of braces not only on curve progression but also on postural stability [15–17]. Postural balance deficit has been suggested as an etiological factor in the development of scoliosis [1,2]. In addition, the severity of postural imbalance may be associated with curve progression [18]. Although several studies have reported improvements in curve progression due to various orthotic treatments [13,14,19], the effects of spinal braces on postural equilibrium and stability remain unclear.

The design characteristics of braces determine the degree of postural control. Many factors are involved in brace design, including the accuracy of sensory input and freedom to select postural strategies. In this study, the effects of a spinal brace designed to restore sagittal plane deformity on postural control and curve angle were examined.

2. Methods

2.1. Patients

Patients with AIS referred to our unit for conservative treatment were recruited for the study. Inclusion criteria for patients with AIS included age (12–17 years) and a minimum curve progression. Patients who refused to participate in the study or wear a spinal brace, had imbalance problems of neurological or orthopedic origin, those scheduled for spinal surgery and those with lumbar back pain were excluded.

The study was approved by the Research Ethics Board HEK 12/203–34 on December 12, 2012. All patients signed an informed consent form, and along with their parents were informed about the purpose of the study.

2.2. Brace design

Conservative treatment for AIS in study subjects included wearing a specially designed spinal brace, fabricated and fitted by an experienced orthotic technician (Fig. 1). The design of the spinal brace was based on the SPoRT concept of bracing (Symmetric, Patient-oriented, Rigid, Three-dimensional, Active). While maintaining original body shape, the brace also provides symmetrical posture by achieving a three-dimensional action of correction. The brace is invisible under the clothes to increase acceptability among patients. Besides, it provides the ability to move four extremities freely and trunk (flexion, bending and rotation). The concept requires customized construction of the brace according to the patient's individual requirements [12].

The main functions of the brace were to actively correct lateral deviation and rotation and restore sagittal plane deformity by pushing upward from the pelvis, thereby achieving symmetrical vertebral column posture. The brace allowed patients to move freely and caused minimal cosmetic discomfort. Moreover, complaints about pain or physical discomfort were minimal, except in warm climates due to the heat. Therefore, holes were drilled in the frame of the brace to improve air circulation. Collaboration of the patient, orthopedist, physiotherapist, and family is essential for satisfactory treatment and follow-up visits.

The brace was prepared from medium density polyethylene, and it extended from the thoracic region to the iliac crest, which provided some flexibility in hip movement and preserved physiological lumbar lordosis. A thoracic window in the front of the brace allowed thoracic expansion and mammary growth. The brace was designed based on principles of symmetry; therefore, a window was made opposite the apex of the curve to provide free space for movement while maintaining a constant correcting force at the apex of the curve. Individual properties of patients' conditions were taken into consideration during fabrication. All patients were instructed to use the brace for 23 h everyday. Time without the brace was allowed for exercise and recreation.

2.3. Measurements

Demographic characteristics of the patients, including age, sex, height, body weight, and detailed medical history, were recorded at the time of initial assessment (baseline). Anterior and posterior X-rays of the spine in braced and unbraced conditions were obtained. Cobb angles were measured. Spinal curvatures were classified according to the King–Moe classification [20]. This classification involves local measurement of Cobb angles to formulate a holistic understanding of the spinal deformity. A King–Moe Type I spine is doubly curved in the lumbar and thoracic spinal regions. A Type II spine is also doubly curved in these regions, although the lumbar curve is less prominent than in the King–Moe Type I spine. A Type III spine has a single primary thoracic curve and a normal lumbar curve. In a Type IV spine, a very long thoracic curve is evident. A Type V spine has a double thoracic curve and may also have a third compensatory curve in the lumbar region [20]. Cobb angle measurements were repeated after eight weeks.

Fig. 1. Brace photo.