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Clinical Study

Effect of long-term orthotic treatment on gait biomechanics in adolescent idiopathic scoliosis

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Abstract

BACKGROUND CONTEXT: A previous study showed subtle biomechanical changes in the gait of unbraced adolescent idiopathic scoliosis (AIS) patients such as a reduction of pelvic, hip, knee, and ankle displacements. However, lumbopelvic muscles' timing activity was bilaterally increased during gait and correlated to excessive oxygen consumption as compared with healthy subjects. Usually, a brace, when indicated, is worn strictly for 22 hours every day in skeletally immature idiopathic scoliotic girls. To our knowledge, no study has assessed the long-term brace effect (6 months) on functional activities such as level walking.

PURPOSE: To assess the stiffening effects of 6 months' brace wearing on instrumented gait analysis in girls with thoracolumbar/lumbar adolescent idiopathic scoliosis.

STUDY DESIGN/SETTING: Clinical prospective study.

PATIENT SAMPLE: Thirteen girls diagnosed as progressive adolescent idiopathic scoliosis with left thoracolumbar/lumbar curves (curves ranging 25°–40°).

OUTCOME MEASURES: All patients underwent a radiographic and instrumented gait analysis, including assessment of kinematics, mechanics, electromyography (EMG), and energetics of walking.

METHODS: The scoliotic girls were prospectively studied at S1 (before bracing) and 6 months later at S2 (out-brace: treatment effect). The gait parameters were compared with those of 13 matched healthy girls. A *t* paired test was conducted to evaluate the effect of the 6-month orthotic treatment in AIS girls. Student *t* test was performed to compare the scoliotic group at S2 and the healthy subjects to identify if the observed changes in gait parameters meant improvement or worsening of gait.

RESULTS: After 6 months of orthotic treatment in AIS, thoracolumbar/lumbar curves and apical rotation remained reduced by 25% and 61%, respectively. During gait, frontal pelvis and hip motions were significantly increased. Muscular mechanical work increased becoming closer but still different as compared with healthy subjects. Bilateral lumbopelvic muscles were almost 40% more active in AIS at S1 compared with healthy subjects and did not change at S2 except for the erector spinae muscles EMG activity, which decreased significantly. Energy cost exceeded by 30% in AIS at S1 compared with healthy subjects and did not change at 6 months' follow-up.

CONCLUSIONS: After 6 months of orthotic treatment, in an out-brace situation, the main structural thoracolumbar/lumbar curve remained partly corrected. Frontal pelvis and hip motion increased, contributing to an improvement of muscular mechanical work during walking. EMG activity duration of lumbopelvic muscles did not change except for the erector spinae muscles,

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which was decreased but without any beneficial change in the energy cost of walking. In summary, brace treatment, after 6 months, did not significantly influence the gait variables in AIS girls deleteriously, but did not reduce the excessive energy cost, which was 30% above the values of normal adolescents.

Keywords: Idiopathic scoliosis; Orthotic treatment; Gait; Energy; Muscle

Introduction

Bracing is commonly prescribed for skeletally immature adolescent idiopathic scoliosis (AIS) with progressive curves greater than 25° [1–4]. Most braces are strictly worn (22/24 hours every day) [5,6] until the end of the residual growth, which corresponds to a period of 1 to 3 years. Several studies have investigated the immediate biomechanical effects of bracing on the spine, such as the interface pressure generated at the compression pads [7], radiological correction [1,8,9], and intragastric pressure [10]. Walking, which is the most common functional activity, has been previously analyzed in experimental protocols for the study of functional disabilities in AIS with a brace. Thus, the Milwaukee brace lowers energy expenditure during walking [11] by reducing chest mobility. Both rigid and more flexible braces reduce pelvis and hip kinematics [12]. Back muscle electromyography (EMG) patterns while walking are not changed with the brace as compared without the brace [13].

So far, long-term (>6 months) follow-up of orthotic-treated AIS patients have been limited to assessing the effectiveness of brace treatment in terms of radiographic curve progression, pain, quality of life, and psychological effects [14–22].

Many AIS patients reported that this long-term, daily restricting orthotic treatment forces them to greatly limit social activities [23] or habitual relations with others because of early fatigability and mobility restrictions [12]. However, no study, to our knowledge, has assessed the long-term effects of strictly worn braces on walking and its spatiotemporal, kinematic, mechanical, EMG, and energetic parameters in AIS.

Furthermore, considering the effect of scoliosis progression on gait parameters, our two previous studies [24,25], performed on scoliosis patients before any treatment, have shown that the scoliosis deformity generated changes in gait parameters compared with healthy subjects. These changes included a reduction of the frontal pelvic, hip, and shoulder motion; a decrease in muscular mechanical work; and an increase of EMG activity duration of the paravertebral muscles associated with the excessive energy cost of walking with as consequence poor muscle efficiency. The scoliosis patients included in these studies who were treated with orthotics were retested after 6 months of brace-wearing to assess the long-term effects of orthotic treatment on these gait parameters. Because it is logical that the radiological scoliosis curve correction would no longer be influenced by the orthotic treatment as soon as the brace (currently worn 22 hours per day) is removed for 18 hours, we expected to observe the same phenomenon on the gait parameters.

The objective of this study was therefore to assess the effect of orthotic treatment on gait variables (kinematic, EMG, mechanical, and energetic variables) in females with thoracolumbar/lumbar AIS after wearing a brace for 6 months. We hypothesized that the long-term effect of bracing treatment could induce a stiffening of the body, affecting functional daily walking.

Material and methods

Study population

Thirteen progressive [26] girls with AIS (14 [12–15] years, 157±8 cm, 48.5±8.4 kg, 19.5±1.9 body mass index) with a left thoracolumbar/lumbar primary structural curve according to the Lenke classification [27] were enrolled in the study. Patients presenting with leg-length discrepancy greater than 1 cm, locomotor disorders, back pain, neurological abnormalities, or any previous treatment for their back were excluded. Inclusion criteria for the indication of brace in AIS were [4,5]: skeletal immaturity, Risser 0 to 2, premenarcheal or postmenarcheal by less than 1 year, and a 25° to 40° Cobb angle on posteroanterior view radiographs.

Patients were instructed to wear (22 hours per day) a custom-made rigid underarm thoracolumbosacral orthosis (Chêneau brace) [28] molded by an experienced orthotist. Marks were made on the straps of the brace to ensure that the correct pressure was applied.

Each subject signed a consent form and participated freely in the study as approved by the local ethics board. Compliance was estimated by the orthopedic surgeon reviewing the patient at the 6 months' clinical follow-up. A questionnaire to assess compliance was not administered.

The patients underwent radiographic examination without the brace (removed for 18 hours) and gait assessment (Fig. 1).

Radiological assessment

A posteroanterior full-spine standing radiograph was performed to evaluate the main Cobb angle curve [29], frontal body balance [30], and Risser sign [31] as described previously.

Instrumented gait analysis

The gait was assessed using a three-dimensional analysis, including synchronous kinematic, EMG, mechanical,